POWER

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Two Ways of Going to Work

Both are getting the same salary now, but not for long

(Suggested by the letter from Milton W. Elmendorf, Wilkinsburg, Penn., page 515)

Hydro-Electric Power Plant at Chittenden, Vt.

By Thomas Fraher

SYNOPSIS—This hydro-electric development operates under a head of 430 ft. and was built to utilize the storage of a reservoir already provided, the water of which performed no work in flowing to the lower reservoir through East Creek. The plant consists of two 1850-hp. turbines, which drive two 1000-kw. generators. Provision has been made for a third unit.

The hydro-electric plant of the Pittsford Power Co., which is located in the town of Chittenden, about seven miles north of Rutland, Vt., presents an interesting feature in the fact that it operates under a higher head than any similar plant in the East.

The purpose of this development was to utilize the storage of a reservoir already in existence, the waters from which, in flowing along what is known as East Creek to a lower reservoir, performed no useful work. As the lower body of water served a hydro-electric plant of 1200-kw. capacity, erected in 1905 and in active operation, no water could be diverted from this basin, and the logical location of the new station was one as near to the elevation of the lower reservoir as nature would permit, to secure the maximum head, and so placed that all water discharged through the new plant would be available for subsequent use at the existing station already in operation.

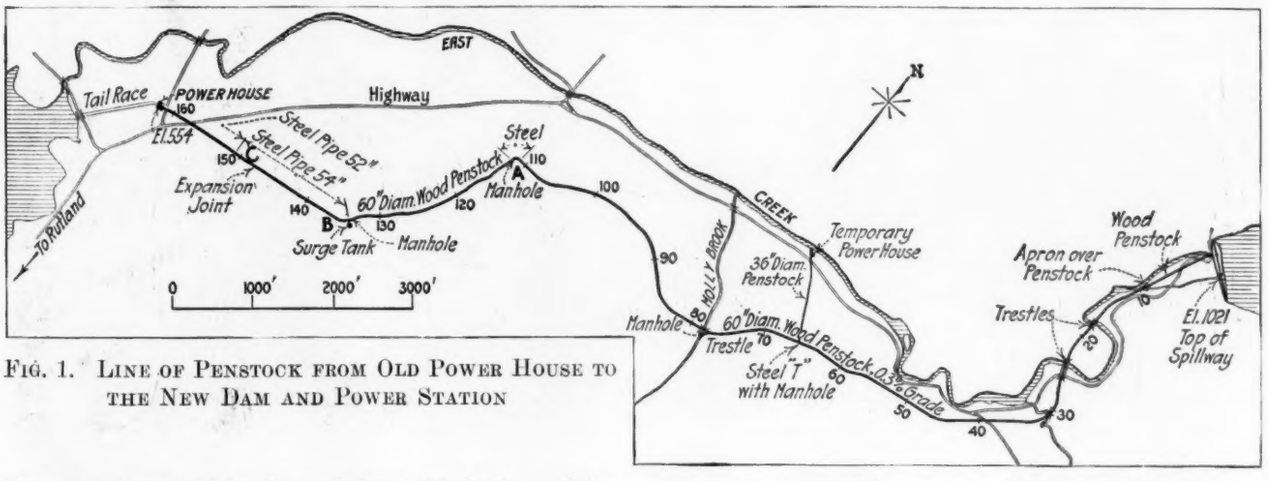


Fig. 1. Line of Penstock from Old Power House to the New Dam and Power Station

The upper reservoir, although several times larger than the lower, is of comparatively small capacity, the quantity of water impounded being about one billion cubic feet. The area of the reservoir is 2414 acres, and that of its watershed about twenty-seven square miles. Notwithstanding the static head of 487 ft., the small amount of water available makes the horsepower development rather limited. The capacity of the two units at present installed is about 3300 hp., but provision has been made for the future addition of another similar unit.

After surveys and examinations of the territory, the location of the Pittsford Power Co. plant was decided upon as shown in Fig. 1, where it is possible to utilize the maximum head with a minimum length of penstock.

A study of the contours of the East Creek valley showed that by keeping the pipe line on the east side a suitable gradient of 0.3 per cent. could be obtained, which would permit a wood-stave penstock being built from the outlet of the reservoir to a point about 2700 ft. east of the proposed power house. At this latter location the drop is abrupt, thus requiring a steel penstock from there to the power house.

From the outlet of the dam of the Chittenden reservoir, a wood-stave penstock, 5-ft. inside diameter, extends 13,400 ft., except a section *A*, where the contours compelled the introduction of a $\frac{5}{16}$-in. steel pipe on an 80-ft. radius curve. At *B* there is a curve of 80-ft. radius, 75 ft. long, formed of three lengths of $\frac{5}{16}$-in. steel pipe, the first of which is a taper section, changing from 60 to 54 in. From *B* to *C* the diameter of the steel pipe is 54 in., and from the latter point to the venturi meter, just outside the power house, it is 52 in. The thickness varies between $\frac{5}{16}$ and $\frac{9}{16}$ in.

The elevation of the water in the Chittenden or upper reservoir, when the flashboards are on the dam, is 1021 ft., and the center of the outlet pipe in the dam is 975 ft., so that, dependent upon the stage of the water in the reservoir, the initial head on the penstock may vary between 46 and 5 ft., which is about as low as it is desirable to operate.

Connection between the outlet valve of the reservoir and the penstock is made through a steel nipple, which has a manhole and a 24-in. nozzle. Upon this nozzle was placed a 24-in. steel pipe, 55 ft. high, to act as a vent to prevent collapse when drawing off the water. This pipe was protected by a double frost casing of wood staves and is heated electrically by an old car heater.

For a distance of about 1400 ft. from the outlet of the dam the penstock was made of spruce cut from the company's tracts near the site of the work. The spruce staves were $2\frac{5}{8}$ in. thick, made from 3x8-in. and 3x6-in. stock and milled so that it took 21 staves from the wide stock and 7 from the narrow to make a section of pipe.

The wood-stave penstock, except the first 1400 ft., is made of live Douglas fir, 2½x6-in. stock, kiln dried, the finished staves being 2⅛ in. thick and 36 pieces being required to make a section of 60 in. diameter.

All bands were ⅝-in. diameter openhearth steel, a complete band consisting of two pieces, one having standard heads at each end and the other having 7-in. rolled threads at each end.

The spacing of the bands varied between 6½ in. at the dam, where the maximum head would be 46 ft., to 3· in. at the end of the wood-stave section, where the maximum head would be 85 ft. Manholes of pressed steel are provided at intervals, as indicated.

1000-kw. generator, together with the necessary auxiliary apparatus, and to keep this plant in operation until the permanent plant could be built and a similar unit installed, whereupon the apparatus in the temporary station would be removed to the permanent power house.

Early in February work on the temporary power house was abandoned, as it had been decided to build the entire project, and work was begun on the excavation necessary to provide a uniform gradient of 0.3 per cent. for the pipe line.

Tile drains of 12-in. diameter were put in at the places where fills were to be made. The tile was laid in a bed of clean sand or gravel, and the joints cemented. Small

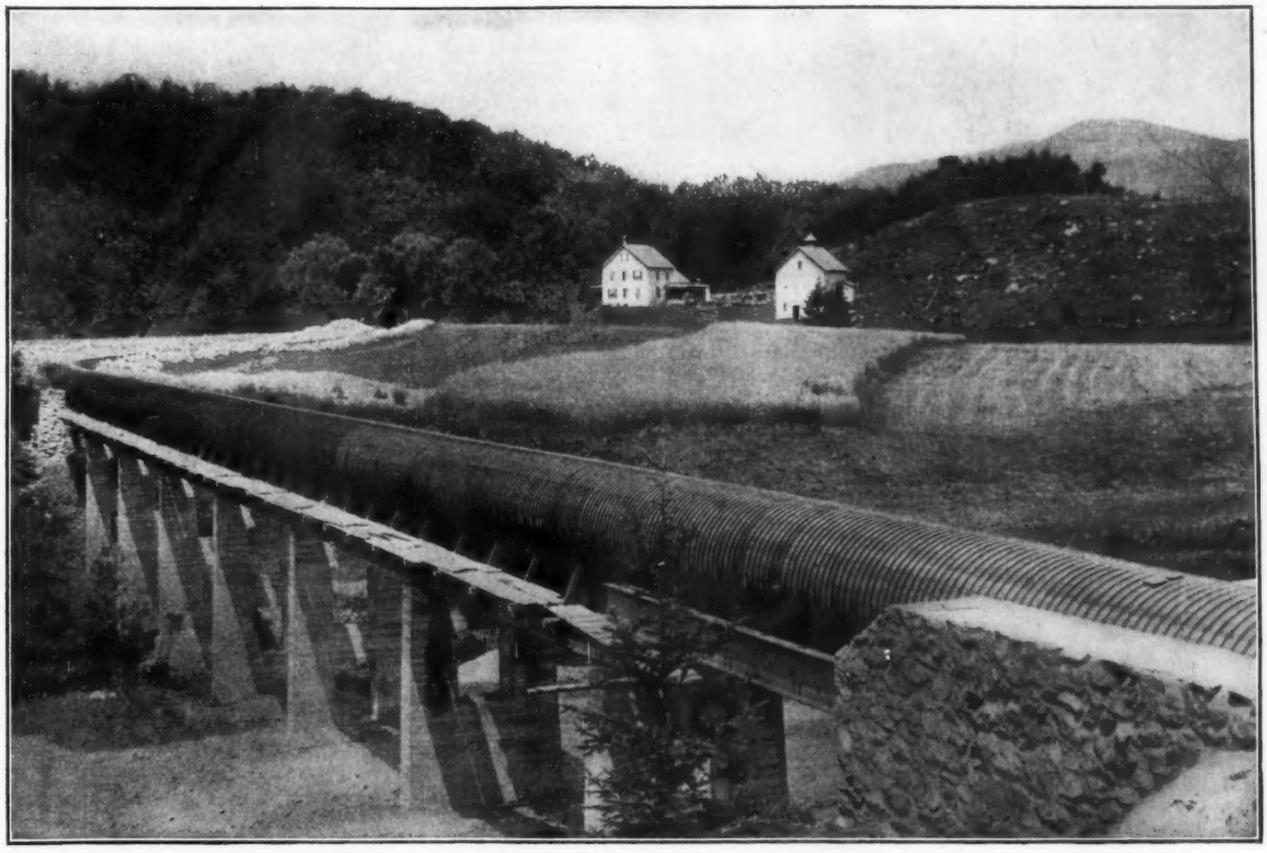


FIG. 2. CONCRETE TRESTLE SUPPORTING THE PENSTOCK

At a point near where the wooden and the steel pipes join, an equalizing tower 14 ft. in diameter and 90 ft. high is located. The elevation of the bottom of this tower is 950, or 16 ft. above the center line of the end of the wood pipe, and the top of the tower is 19 ft. higher than the flashboards at the dam. This tank consists of one 10-ft. ring at the bottom and sixteen 5-ft. rings above. Each ring is made up of three segments, bent and dipped before shipping.

About Jan. 1, 1914, it was decided to undertake the construction of part of this development by the company forces, as it had a contract which stipulated that from July 1, 1914, it was to deliver a maximum of 600 kw. To live up to this agreement, provision was made to build the main penstock from the dam to a point about 6500 ft. distant, where at *D* a right-angle turn was made, and by running a distance of 1080 ft. a static head of about 200 ft. would be available. It was intended to set up at this point one of the two 1875-hp. turbines and a

rubble walls were built at the intakes and outlets of these culverts.

The wood-pipe line crosses East Creek twice, requiring two trestles, and also crosses a small brook. The trestles have rubble abutments, and the intermediate piers are of a uniform type, being 2x8 ft. at the top, with the front and back vertical and the sides battered ½ in. per foot from the top. They are of 1:2:4 gravel concrete, reinforced with vertical and horizontal bars. Fig. 2 is a photograph of the largest trestle.

The Chittenden dam is 1000 ft. higher than Rutland and 10 miles distant; the power house is 500 ft. higher and 7 miles distant. With the exception of about two miles near the city, the roads are poor. The freighters hauled at the rate of $3 per ton, and in all about 2000 tons had to be moved. The 30-ft. lengths of steel pipe varied between 3¼ and 5 tons.

About 40 per cent. of the wood stave line was composed of curves. With the exception of the stretch between *A*

FIG. 3. CHITTENDEN POWER HOUSE

and *B*, all curves were either 360 or 300 ft. radius. In the locality mentioned there were some curves of these radii, but also a few sharper ones, notably one at about 175 ft. radius. The average construction progress on curves was about 200 ft. per day of 10 hours, and on tangents about 300 ft. The best day's work was 420 ft., made on a tangent where the staves averaged about 25 ft. in length.

At points where the stave pipe joined the steel pipe, the latter had the rivets countersunk for a distance of 4 ft. from the end, and presented a smooth outside surface for the staves to be fitted over.

It became evident in the latter part of May that the permanent power house could not be in operation by July 1, and so it was decided to build the temporary installation. Therefore, work was resumed with a view to getting in the foundations for the turbine and generator.

At the point *D*, Fig. 1, a steel tee had been inserted in the main line, and from this a 3-ft. penstock line 1080 ft. long, of which the upper 580 ft. was of spruce and the lower 500 ft. of ¼-in. steel plate, single lap, with ⅝-in. rivets, was built. The spruce staves were milled by the company, and one-piece bands were used. The steel pipe was sublet to a local firm, which made it right at the site of the work.

The ends of the steel tee were punched for ⅝-in. bolts on 3-in. centers and the staves of the penstock were bolted to the steel tee. At the back of the tee a connection was made to a 2-ft. diameter steel pipe, 80 ft. high, erected to fulfill the function of a surge tank and vent.

About three feet from the downward end of this steel tee a 5-ft. diameter ¼-in. steel boiler head was set up as a bulkhead to divert the water through the temporary power-house penstock and to permit turning on the water before the rest of the line was finished. Oakum was packed in wherever possible between the bulkhead and inside of the pipe.

The temporary plant was in operation until Oct. 1, at which time the machinery was dismantled and placed in the permanent plant. The penstock was taken apart and utilized at Molly Brook, where a small collecting basin was built at an elevation of 80 ft. above the penstock at that point and the water conveyed through the 3-ft. penstock into the main pipe line.

The steel pipe was placed alongside the trench by the

FIG. 4. INTERIOR OF THE CHITTENDEN POWER PLANT

company and the pipe contractor's gang rolled the lengths in the trench and used two small derricks to aid in bolting up.

The reaming, riveting and calking followed in the order named; an expansion joint was placed 1448 ft. from the dam to allow for movement of the pipe previous to filling it with water and covering it.

The surge tank is on a rocky knoll at the point *B*. The concrete foundation is, on an average, 3 ft. thick, and six 2½-in. stay-bolts, fitted into holes drilled in the rock and also embedded in the foundation, provide against movement. The connection between the penstock and the tank consists of a 48-in. steel pipe. Between this pipe and the end of the wood pipe, a distance of about 10 ft., is a 60-in. butterfly valve. At the bottom of the penstock, just in front of this valve, is a 12-in. blowoff valve designed to pass such water as might leak past the butterfly, so that no water could leak down the pipe when not so desired. There are manholes in the steel pipe near the butterfly valve and at two intermediate points and the pipe may also be entered through the turbines.

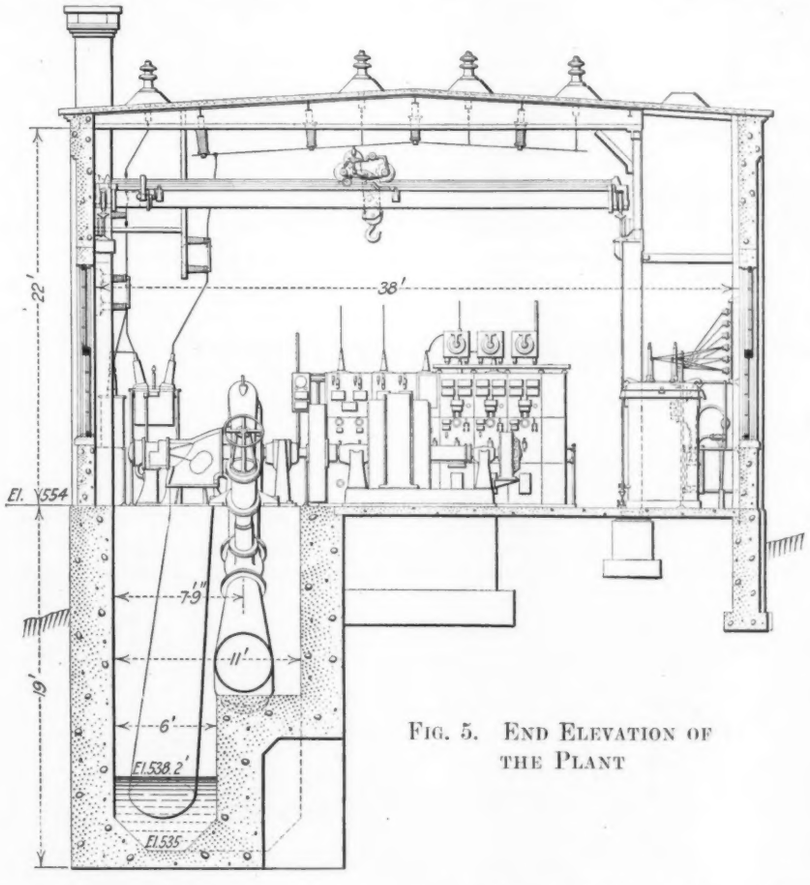


FIG. 5. END ELEVATION OF THE PLANT

The surge tank has a manhole near the bottom, and a ladder outside affords access to the top. After testing, a frost casing 18 ft. in diameter, or 4 ft. larger than the diameter of the tank, was built. Old 2-in. planks of various widths were used, butted off square without the edges being beveled radially. The first set was placed so that adjacent pieces broke joints, nailed plumb in place, and then ⅝-in. bands on 2-ft. centers were clinched tight. The remaining sets were easily added. At the top is a silo roof, in which a door is arranged to admit air if the drawing off of the water should tend to form a vacuum. The frost casing was covered with a coating of cement-lime plaster applied to a wire lath as a protection against fire and decay; provision was made for heating during the winter months.

POWER HOUSE

The permanent power house is a single-story structure 38x71 ft. inside and 22 ft. high (Fig. 3). The foundation walls are of 1:2:4 gravel concrete of an average depth, excepting the south wall, of about 6 ft.; they are 18 in. thick and rest on a 12-in. footing course 3 ft. wide. The south wall, which forms one side of the tail race within the building, has a depth of from 12 to 19 ft. and is 30 in. thick.

The walls of the building consist of a 12-in. double-faced brick wall, pilasters 28 in. square being introduced so as to divide the north and south walls into four bays and the east and west into three bays.

The roof is framed of three transverse girders, between which are standard I-beams, and is covered with a 4-in. concrete slab reinforced with triangle-mesh reinforcing. The roof is waterproofed with six layers of tarred felt and stone screenings.

The steel penstock enters the building normal to and through an opening in its front wall, and about eight feet from the south wall. Three nozzles lead from the penstock to feed the turbines; they are 24 in. inside diameter and flanged to take a 24-in. valve, fitted both for hydraulic and hand operation. When the pipe had been filled and tested the penstock was heavily anchored with concrete.

The tail race lies at the south side of the building and is 11 ft. wide, and 18 ft. deep. Over the west or back end of this building was built a small room, in which is installed a low-pressure boiler for heating the building.

The turbines are placed over the tail-race, each being carried by a pair of 12-in. H-beams, secured by anchor bolts and concreted in. Space has been provided for three units, although at present only two have been installed. The turbines, of the Francis type with wicket gates, are of 1850 hp. at 720 r.p.m. under a 430-ft. head at full gate opening. All the gate-operating mechanism is on the outside of the flume, and is controlled by a governor of the direct-connected type, arranged for electric control. The runner consists of a bronze runner band with a cast-iron hub, the latter being securely keyed to the turbine shaft. The spiral flume is made of a single iron casting and has the form of a true evolutionary spiral. The gates and the guide ring are made of cast steel, and the gate ring of cast iron. The turbine shaft is made of hammered steel, 6 in. in diameter on the driving end and 4½ in. on the remote end. The driving end of the shaft is fitted to the hub of the 5-ft. 9-in. cast-iron flywheel, which weighs about five tons. The remote end rests in an end-thrust bearing arranged to operate in a bath of oil.

The draft tube is about 15 ft. long and has a diameter of 48 in. at its lower end. To protect the line against undue rise in pressure caused by the action of the governor under the varying conditions of load, a relief valve capable of discharging 30 cu.ft. per second is installed.

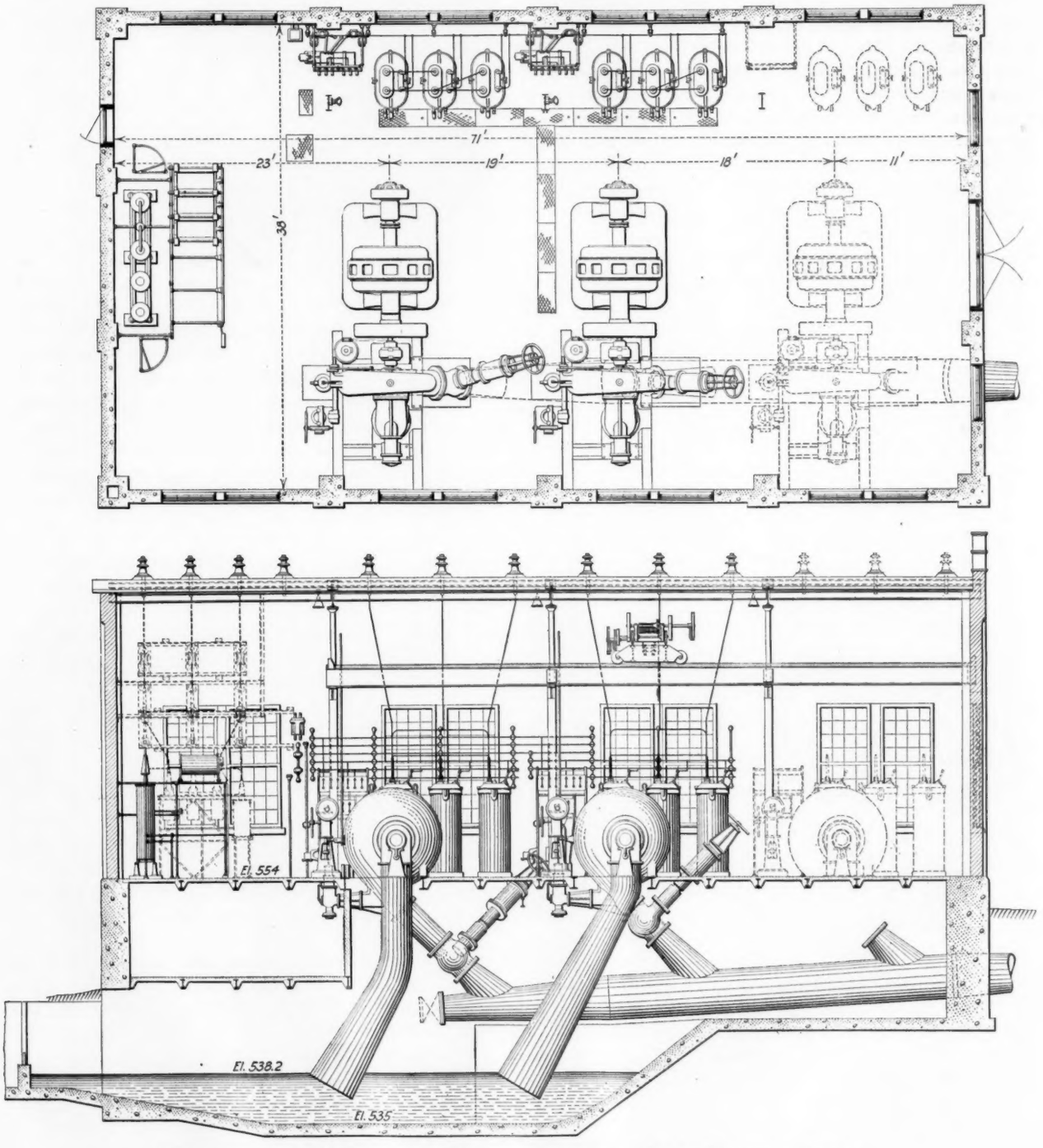
The side of the flywheel remote from the turbine is fitted with a flange, to which a forged flange on the generator shaft is fitted to couple the two together.

An interior view of the power house is shown in Fig. 4. Figs. 5, 6 and 7 are plan and elevation of the power plant. Just outside the power house there is inserted in the pipe line a venturi meter with a 52-in. inlet and 27x 42-in. outlet. Both the inlet and outlet ends of the castings are flanged, and faced and drilled to take the $\frac{9}{16}$-in. flanges of the adjacent steel pipe. The meter is connected to an automatic register indicator recorder.

Electrical Equipment

The station is designed for a maximum continued capacity of 3000 kw. at 44,000 volts and 80 per cent. power factor, this energy to be generated by three units and delivered through two 44,000-volt feeders. Two units and one feeder are now in regular operation, and the third unit and second feeder will be added when necessary to take care of the future increase in load.

Each generator is rated at 1250 kv.-a., 2300-volt, three-phase, 60 cycles; and with a 25-per cent. overload



Figs. 6 and 7. Plan and Side Elevation of the Hydro-Electric Plant

for two hours the rise in temperature is guaranteed not to exceed 55 deg. C. above the room temperature of 25 deg. C. Each generator has its own direct-connected exciter, operating in parallel at 125 volts.

There are at present two banks of transformers, each consisting of three single-phase, 400-kv.-a., 2300-44,000-volt, water-cooled transformers, and with a 25-per cent. overload for two hours, the rise in temperature is guaranteed not to exceed 55 deg. C. above a room temperature of 25 deg. C. Cooling water is supplied from the penstock at a reduced pressure.

The switchboard is of marble and consists of exciter feeder panel with voltage regulator, generator, lighting and a blank generator panel. All control and instrument wiring is installed in iron conduit laid in the concrete floor. As the oil switches are remote-controlled, 125 volts is the maximum on the switchboard.

A 2300-volt bus of copper tubing is supported vertically on the north wall back of and above the transformers. The generators connect to this bus by means of lead-covered, varnished-cambric insulated cables laid in fiber ducts below the main floor, and the usual oil switch and disconnecting switches.

Each transformer bank is connected to the 2300-volt bus through disconnecting switches and to the 44,000-volt outside bus on the roof by means of copper tubing through the roof bushings and a three-pole air-brake switch, this switch being hand-operated from the station floor.

The 44,000-volt bus, three-pole, air-brake switches and lightning-arrester horn gaps are mounted on pipe framework supported on the roof, the entire roof being used for this purpose.

An iron stairway at the west end of the building provides easy access to the roof through a door and landing at the main-floor level.

Electrolytic lightning arresters of indoor type are connected to the horn gaps through roof bushings. The present feeder connects to the 44,000-volt transmission line through a three-pole, 44,000-volt, indoor-type, remote-controlled auto-oil switch and the usual disconnecting switches and choke coils.

PRINCIPAL EQUIPMENT OF CHITTENDEN HYDRO-ELECTRIC POWER PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Turbines	Francis, wicket gate	1850-hp.	Driving main generators	430 ft. head, 720 r.p.m.	S. Morgan Smith Co.
2	Generators	Alternating-current	1250-kv.-a.	Main units	720 r.p.m., 2300 volts, 3-phase, 60-cycle	General Electric Co.
2	Governors	Direct-connected		With main turbines	Electrically controlled	Lombard Governor Co.
2	Exciters	Direct-current		With main generators	Coupled to generator shafts, 125 volts	General Electric Co.
1	Switchboard	Marble		Electrical control of units		General Electric Co.
6	Transformers	Water-cooled	400-kv.-a.	Stepping-up current	2300-44,000 volts, single-phase, 60-cycle	General Electric Co.
	All electrical apparatus in power house, such as switches, lightning arresters, etc.					General Electric Co.

Illumination is obtained from six 250-watt tungsten lamps in deep-bowl reflectors hung close to the ceiling, the outlet boxes and connecting conduit for wiring being cast in the concrete roof. Extra illumination and plug receptacles for portable lamps are conveniently distributed on the walls of the building. Outdoor lighting is provided for the roof by means of street lighting fixtures, thus assisting greatly in inspection and repair at night.

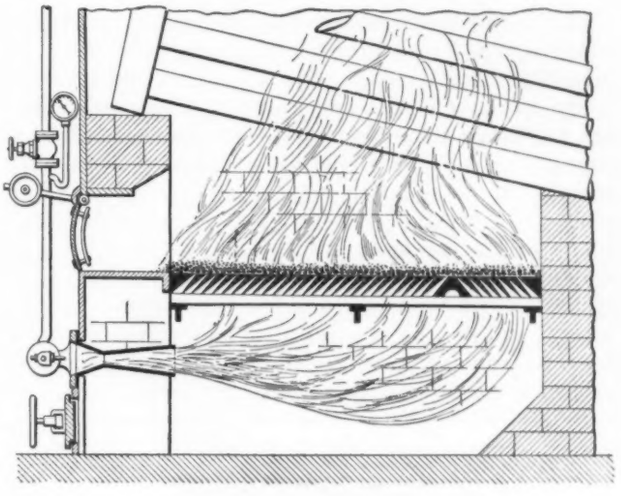
Illumination is controlled from the eight-circuit lighting panel, which is a part of the main switchboard. A double-throw switch mounted on this panel enables the lighting supply to be taken from the 2300-volt bus through a 3-kw. transformer or from the exciter bus.

The permanent power house was placed in operation about Oct. 1, 1914, and the unit from the temporary plant was set up during that month.

The Pittsford Power Co. development was designed and constructed under supervision of W. S. Barstow & Co., engineers and managers, of New York City.

Poillon Furnace Grate

The Poillon grate illustrated herewith is designed to burn fine dust, lignite, coke and other grades of coal. The particular feature is that the direction of burning gases is from the ends of the grate toward the center of the furnace.



POILLON FURNACE GRATE

In the ordinary furnace the liberated gas flows toward the bridge-wall and upward. With this grate the currents are from the front of the furnace toward the rear and from the rear toward the front, caused by the angle of the air spaces in the grate. The result is that the liberated gases from freshly fired fuel at the front mingle with the hot gases from the rear end of the furnace, and their combustion takes place before striking the cooling surface of the boiler tubes.

The mingling of the two currents distributes the flames over a large tube area and prevents the hottest flames from striking the tube in the form of a jet, as would be the tendency were they to go to the tubes with no interruption.

As illustrated, the grate (which is placed on the market by Julian Champeaux, 36 Downshire Hill, London, N. W.) is used in connection with a blower.

Boiler Accidents—A report submitted at the convention of the American Society of Mechanical Engineers in New York City last December contained the following statement:

Every year there averages in the United States between 1300 and 1400 serious boiler accidents, of which 300 to 400 are violent explosions. These accidents kill between 400 and 500 persons, injure 700 to 800 more, and destroy more than half a million dollars' worth of property. In a single explosion, that of the R. B. Grover Shoe Co., at Brockton, Mass., 58 persons were killed, 117 more were injured, $250,000 worth of property was destroyed, and an aggregate of $280,000 was claimed in the personal injury and death suits that were brought. In a period of 46 years, since 1867, over 10,000 people have been killed and over 15,000 injured in boiler explosions

Pre-Efficiency

By Geo. F. Willis

SYNOPSIS—The importance of the preliminary work while laying out a power installation. Only by studying the conditions and selecting the equipment to suit can one expect to have a truly efficient plant.

This is the day of efficiency in all classes of manufacturing, and the successful manufacturer looks for it all along the line. After a plant is built, the operation is closely watched in order that efficiency in all departments may be secured. Many schemes, from piecework to bonus payment, are used, all to add to the one proposition—efficiency.

But how few manufacturers or owners go at this matter from the first inception of the plant! It is decided to build a factory for a certain purpose, costing, say $250,000. It is easy to find architects competent to build the housing, and the plans are made, submitted and accepted. But the power plant, the real heart of the proposition—the boiler and engine equipment, the electrical power to be used for lights and motors, the pumps, economizers, heaters, condensers—all this is usually left to the architects, who are the last people who should have any say as to this part of the outfit, as their experience and efficiency are practically limited to the building itself. They work out the balance of the scheme as best they may, as an accessory to the original in which they are most interested, and men are too often influenced by personal acquaintanceship and prejudice.

The use of oil and gasoline engines, producer-gas equipment, electrical driving and its advantages and disadvantages—these problems are neither thoroughly considered nor gone into expertly, but are usually left to the good or bad judgment of the original designers of the building itself. When it is known that in building a factory costing the amount mentioned, there might be made a saving of 10 per cent., or $25,000, by calling in engineers in the special lines mentioned, their cost being but a small part of the saving named, it is curious that such technical ability is seldom called for, and the factory is built without the owners knowing what might have been saved for the same capacity or what might have been added to the capacity reached, by the advice of technical experts in the particular line for which the factory is built.

The writer is often confronted by the advertisement of some manufacturer of belts, for instance, who will take a whole page in some technical journal to tell about a big belt he has just supplied to some concern. This will be a triple leather belt, 84 in. wide and 160 ft. long, we will say, and he goes on to tell how many steer hides it took to make it, how much it weighs, what it will drive, etc. In the writer's opinion, anyone shows poor judgment who uses a belt any wider than, or even as wide as, 24 in. He also believes that manila-rope transmission for anything in the way of main drives from 50 hp. up is cheaper and better than any belt drive. In the case of such a belt as mentioned, the saving in the original cost by using ropes would be some $2000, and the ropes would have as long life as the belt, with less slippage and a smoother and more positive drive all around. In such a case it is probable that the designers of the plant have seen so many wide belts in other plants that they have no idea anything else could be used. It is a case of mental suggestion.

Take the case of a company building a $75,000 sawmill. It is willing to and usually does build the plant from the plans of the maker of the machinery to be used, who is naturally a much interested party. As a judge of the design the purchaser calls in his old foreman, who has been with him many years, and as he ran the old plant successfully he is considered an authority. He well knows every weak place in the old plant, and he is firmly resolved that in case he has anything to say about the new one, these weak spots will be eliminated. So when the new plans are offered him for his criticism, he rigidly turns down anything that looks like the trouble spots he had to contend with for so many years, and finally approves the plans submitted. He does not know what new troubles the new plant will bring, and he is not capable of selecting from the mass of technical details of machinery offered the best to be used. So the concern buys, and the mill is built. It may run to the satisfaction of the owners, but like a doctor's mistakes, all that have been made are buried; and while it might have been possible to build the same mill for less money, to build a better mill for the same money, to build a mill at the same cost which would produce the same amount of lumber with a few less hands, all this is unknown, and the expert engineer was never called in, everything being left to the judgment of one man who knew all about one mill and nothing of any other.

The writer's experience of something like twenty-five years in designing and building plants has shown him that efficiency rarely begins at the commencement of the operation—where it more properly belongs than at a later period—and that nine out of ten plants are built from crude ideas of owners and employees. One manufacturer who intends building is positive that he will use electrical transmission throughout. He does not know exactly why, but he has read of the great strides that have been made in introducing this system, and as a factory a few blocks away has just been completed and this transmission is used throughout, why should not he use it? It may be that this is the least desirable system for his special requirements, but he does not call in a transmission expert to secure his views and advice. The electrical people are willing to meet him more than half way and confirm his views and wishes. So he spends much money for a power-transmission scheme that does not suit his conditions and is satisfied forever afterward because his factory runs and produces.

No one maker of machinery builds a full line of the best. He may have one or two machines that cannot be equaled, one or two that are about as good as others, and the rest of his line not so good as those built by his competitors. But the tendency is to buy the full equipment from one maker, on a blanket proposition covering the full list of machines required. This, in a way, largely depends upon the salesman that secures the order. Many times the writer has sold the complete equipment for a plant on

the strength of one machine which his company originated, and built better than anyone else. The fact that this machine cost several hundred dollars more to build than was got for it mattered not, as this was made up on the remainder of the order. Six out of ten times we sold the power plant, which we did not build at all, and which we bought as cheaply as we could so long as it approached the requirements—said requirements being suggested by ourselves, of course Had a competent engineer been called in on these jobs, it is likely we would have secured the order for the one machine we built better than our competitors and that the rest of the equipment would have been ordered from other makers—as it should have been.

Were a man to contemplate building a home to cost $75,000 or an office building to cost $250,000, he would first go to the best architects he knew of to procure the plans. They would supposedly have at their command technical engineers who were thoroughly conversant with all building requirements and whose efficiency would be added to that of the members of the designing staff. The plans would be prepared with great care and thoroughness, and after a careful analysis by the owner, would be accepted and built from. Were the same man to contemplate the building of a sawmill costing as much or more, he probably would leave the important part of the whole proposition to "Jim," who had run the old plant for thirty years and who should know just what was needed in a new one.

As to power efficiency, the proper kind and character of the boiler plant, whether steam or gas or electricity should be used, all swings on the opinion of the old employee, whose influence is not to be laughed at either. Good or bad, his advice is followed, greatly to the embarrassment of the expert, should one be called in.

In the city in which the writer lives, is one of the largest and, supposedly, one of the most advanced companies in the world, which has become famous by dividing its profits with its employees, with which strikes are unknown, and whose power plant is one of the sights of the city. It has been shown by technical engineers of high standing, after an investigation lasting for weeks, that by scrapping its beautiful engines—nickel-plated and in a room as beautiful as any parlor—the company could make a saving in fuel and upkeep amounting to many thousands of dollars yearly. Would it do it? No, because a man who had been for years close to the president and had sold the company its valves and small equipment advised against it—said the plant was all right as it was and that the experts did not know what they were talking about. His advice "went," and no change has been made. This simply goes to show the small amount of credence given the technical engineer in matters within his own province, and on which he has absolute information.

In the really great and advanced plants engineers may be found who are employed at salaries running up to $25,000 a year and more, and they are cheap men at the price. But in the half-way plants, the ones costing up to the half-million mark, where the technical engineer is nearly always badly needed, he is seldom called in. It is easy to be too technical, so to speak, but the combination of fifty-fifty—half experience and half technical knowledge—will, when secured for even a small plant, well repay the owners, not only in the original cost, but in the following years of operation.

Just for Fun

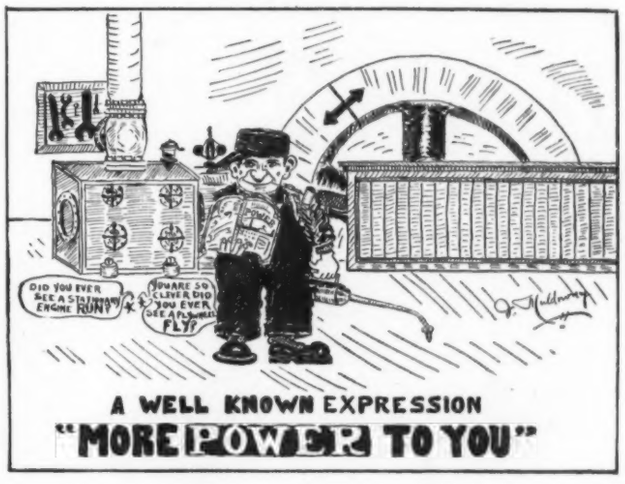
[*More stories of stupidity and ignorance competing with "Some Original Ideas," as printed Jan. 19, 1915.*]

"What's the matter?" asked the superintendent of the second-class licensed engineer on hearing the receiver relief valve blowing fiercely on the 1200-hp. compound engine.

"I guess the exhaust pipe has burst between the engine and the condenser."

"Well, the vacuum is up to 27 in., isn't it?"

But the engineer was making haste to start the larger engine and did not wait for argument. The superintendent, who had formerly been the chief in that station, walked over to the low-pressure side of the engine and pushed the reach rod up forward on the governor, and the relief valve stopped blowing. The engineer returned hastily to see what had caused the engine to become quiet so suddenly. He was cautioned not to tell anyone that he thought the exhaust pipe on a condensing engine had burst with 27 in. of vacuum, but thereafter to watch the governor on the low-pressure side to see it did not unhook again, leaving both steam valves closed.—*R. A. Cultra, Cambridge, Mass.*


DID YOU EVER SEE A STEAM ENGINE RUN?
YOU ARE SO CLEVER DID YOU EVER SEE A PLUMBER FLY?
A WELL KNOWN EXPRESSION
"MORE POWER TO YOU"

A young man recently out of college secured employment as helper around a power plant in an industrial establishment. One day the engineer was called to another part of the plant and left the young man alone in the power house.

After a time the engineer noticed a cloud of steam coming from the blowoff pipe. He did not pay much attention to it at first, thinking that the young man had too much water in the boilers and wanted to blow down a little, but when the blowing had continued for some time he started for the power house to investigate.

Upon arriving, he found that a gage-glass had broken and that the helper had the blowoff valve wide open. When questioned concerning his reason for having the valve open, he said that he wanted to let out the pressure so that he could put in a new glass.

It might be well added that the young man had not studied engineering while at college, but is now a good engineer and has had some six or eight years of experience in the "school of hard knocks" since the incident related.—*Earl Pagett, Coffeyville, Kan.*

Diesel-Engine Installation at Palo Alto

By Herbert Haas

SYNOPSIS—By installing a 300-hp. Diesel engine to carry the day load and using one of the steam units to help out on the peak, a saving of about $6000 has been effected. Heavy California residue is used.

In 1913 the City of Palo Alto, Calif., contemplated replacing its old and rather wasteful steam engines with a steam turbine of excess capacity above the equipment then in operation, which consisted of a cross-compound, slide-valve engine coupled to a 200-kw. alternator, a similar engine driving a 100-kw. alternator, both operating noncondensing, and a single-cylinder, simple engine, with Corliss valve gear, belted to a 50-kw. generator. The two larger engines furnished practically all the load, which for a short period, between 7 and 10 p.m., rose to 330 kw. The steam turbine was to be a 500-kv.-a. unit, operating condensing, its excess capacity being intended to take care of expanding power and light business.

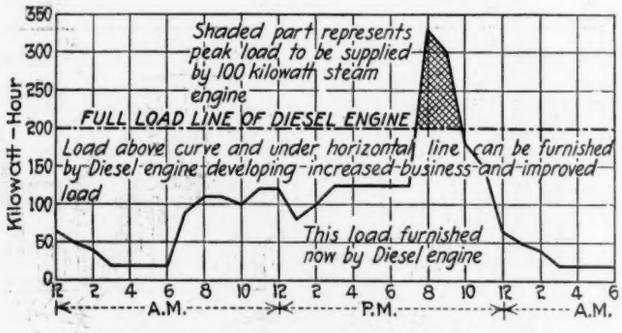

Shaded part represents peak load to be supplied by 100 kilowatt steam engine
FULL LOAD LINE OF DIESEL ENGINE
Load above curve and under horizontal line can be furnished by Diesel engine developing increased business and improved load
This load furnished now by Diesel engine
Kilowatt - Hour
350
300
250
200
150
100
50
0
12 2 4 6 8 10 12 2 4 6 8 10 12 2 4 6
A.M.
P.M.
A.M.

Fig. 1. Load Characteristics for 24 Hr.

Fig. 1 shows the load characteristics during 24 hr., based on a yearly average of the load in 1912. It will be noticed that it is a typical lighting load, only a portion of the power being used in the daytime to operate pump motors. With a load factor, then, of about 30 per cent., this would have become still more unfavorable after the installation of a 500-kv.-a. turbine, for the load would have been around 20 per cent. of the rated capacity of the turbine during the greater part of the time.

Therefore, the writer advocated the installation of a Diesel engine, which, to save in initial investment, was to be of moderate size only, sufficient to carry the entire load except between 6 p.m. and 10 p.m., when one of the existing steam engines was to operate in parallel with the Diesel engine to supply the peak load. The average fuel consumption of the steam plant was 11,000 lb. per day for an average output of 2620 kw.-hr. per day, or 4.2 lb. of fuel oil per kilowatt-hour. It was figured that the Diesel engine would furnish 2400 kw.-hr. (operating at fractional loads, as shown in Fig. 1) with a fuel consumption of 1800 lb., and that the 100-kw. engine unit, operating at full load, would furnish the other 200 or 250 kw.-hr. with a fuel consumption of about 4 lb. per kw.-hr., or 800 to 1000 lb. of fuel oil, in addition to a moderate amount of oil to keep one of the boilers always under steam as a stand-by. Thus, about 22 to 24 bbl. of fuel oil, costing 90c. per bbl., could be saved per day. Against this saving had to be charged interest and amortization on the capital invested in the Diesel engine plant, the slightly higher cost of cylinder lubrication and maintenance. It was thus figured that a saving of $6000 to $7000 per year could be made by the installation of a Diesel-engine set. The operating force was not increased, so the labor item remained the same. It will be seen from the load curve that the Diesel engine would be operating only at about 50 per cent. of its capacity during the day, so that considerable reserve capacity was available for a future increase in load during this period, and any increase in the peak load could still be furnished by the existing steam equipment.

One of the requirements of the engine was the burning of California crude oils or residues, of the same or similar quality as that which is burned under the boilers. The power plant is some distance from the railroad, the fuel oil being pumped to it through a pipe line, which would make it difficult to supply two different oils, one for the boilers and the other for the Diesel engine.

In view of the extensive development of this type in Germany, and after thorough investigation, the Körting Diesel engine was selected, as this engine was found to be giving excellent service in Mexico, running on the heavy asphaltic oils and residues similar to the California oils. The engine is of horizontal construction and has four cylinders. The shaft is extended, and carries the flywheel and the alternating-current generator between the left outer main bearing and an outboard bearing. Beyond the outboard bearing there is a further shaft extension, to which are keyed the armature and commutator of a 10-kw. exciter. The shaft is forged in halves, coupled together between the halves of the engine. To the right-hand shaft end is bolted a crank disk, from which is driven the air compressor. Each shaft section has two cranks, set at 180 deg. The generator is a two-phase, 60-cycle, 40-pole Fort Wayne machine, wound for 2300/2400 volts, and rated at 250 kv.-a., which at 80 per cent. power factor is equivalent to an output of 200 kw.

The pistons are of trunk pattern made especially long to reduce pressure exerted through the crank and piston pins and prevent wear of the cylinder liners. The valves are seated in the cylinder heads, and are all easily accessible, being mounted in individual cages, and can be quickly exchanged. This is of importance, as the exhaust and fuel-injection valves have to be cleaned monthly; spare valves are put in their places and the removed valves are then cleaned at leisure, and kept in readiness.

The governor and valve-gear shafts are operated directly from the main shaft through helical gears running in oil. The governor shaft operates the engine governor, lubricating pumps, and fuel pumps. Of special note is the construction of the fuel pump and the fuel injector. The pump does not have to force the oil against the injection air stored around the fuel-valve needle at a pressure of 800 to 900 lb., a practice common to many

Diesel engines. Instead, the pump works at just enough pressure (only a few pounds) to lift the oil into a chamber in the fuel injector during the suction stroke of the piston. The governor can, therefore, act directly on the pump plunger and vary its stroke according to the exact fuel requirements of the engine, proportionate to its load. The fuel injector has no needle valve, but consists of an open Körting atomizing nozzle. A few degrees before the completion of the compression stroke, a valve in the fuel injector connecting with the injection-air supply pipe is opened, admitting the highly compressed air, at 800 to 900 lb. which carries the fuel-oil charge (stored in the injector during the suction stroke) into the cylinder, at the same time completely atomizing it.

Each cylinder has its individual fuel pump, two pumps being mounted on each valve-gear shaft. The Hartung governor acts on all four pump plungers simultaneously, through wedges which increase or decrease the throw of the plungers with an increase or decrease in the load of the engine. This method of governing is very sensitive, the engine adjusting itself instantly to changes in load.

Another feature worthy of note is the method of starting. Instead of using high-pressure air, which takes considerable power to compress, the engine is started with air at 220 lb. and can be started with a pressure as low as 110 lb., if necessary. The air is stored in a sheet-steel receiver. This method of starting is made possible by having the exhaust valves open during the compression stroke, so that the cylinders work against atmospheric pressure only; when the engine is up to speed, the sequence of the valve play is changed, the air is compressed, and the fuel charge is admitted, the exhaust valves then discharging the products of combustion.

The air for starting the engine and the injection air for atomizing the fuel and forcing it into the engine cylinder is furnished by a three-stage compressor, the low-pressure stage being vertical, the intermediate and high-pressure stages being tandem horizontal cylinders. Between each stage there in an intercooler and oil separator, and the compressor cylinders are all water-jacketed for cooling. The interposition of coolers and oil separators is an important safeguard to prevent explosions. The injection air is stored in two wrought-steel bottles, 8-in. diameter by 6 ft., of which one only is in use, the other acting as a reserve.

The oil flows to the fuel pumps by gravity from a supply tank holding one day's supply and supported on a shelf attached to the wall of the engine room. It is pumped to this tank from the concrete main storage tank, which is built into the ground outside the power house. This fuel oil, being a residue of California crudes (topped oil), has to be heated on account of its high viscosity. This is usually done by using the heated jacket water of the engine. For starting, a gas oil is used (Standard Oil Co.'s Star fuel oil) and, after a few minutes' operation, the engine and circulating water are warm enough to substitute the residue. At Palo Alto, however, the latter is now heated by steam and the engine runs continuously on the residue.

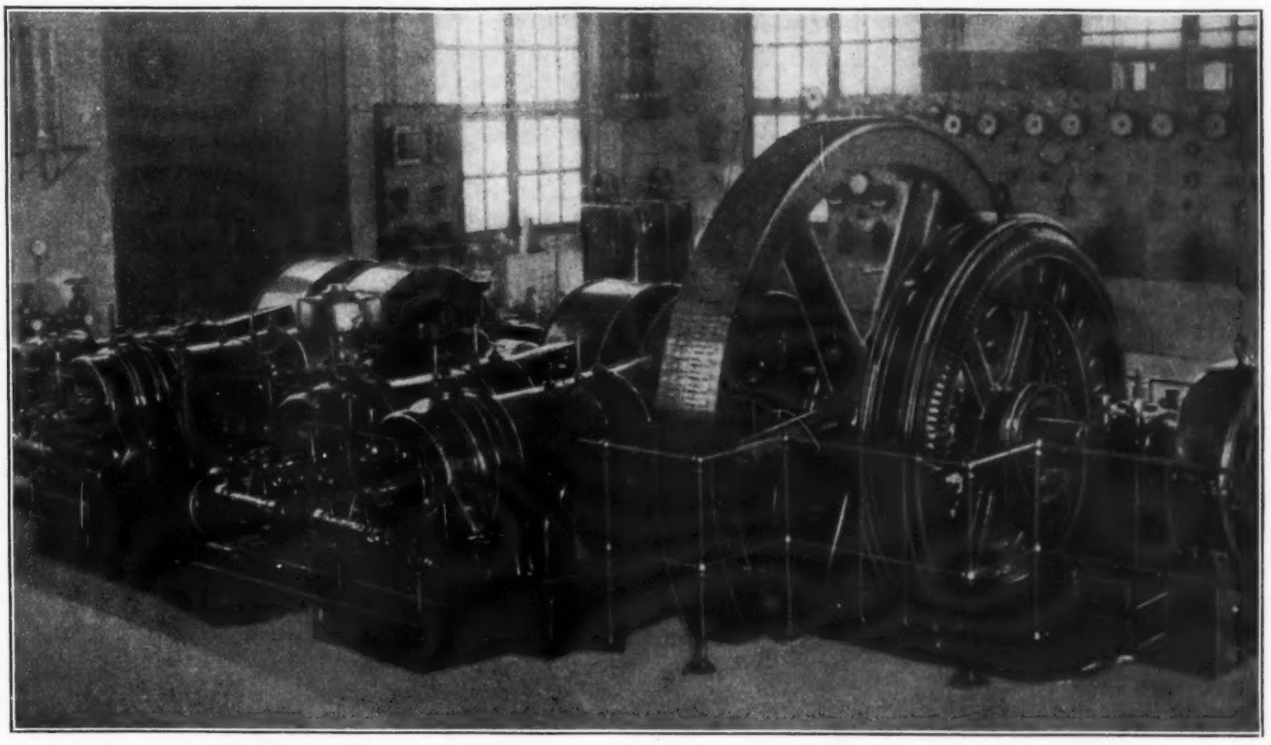


FIG. 2. INSTALLATION OF KÖRTING-DIESEL ENGINE AT PALO ALTO, CALIF.

The air intake for the engine and for the compressor is on the outside of the power house, the air main and individual air conduits leading from it being built into the engine foundation and connecting with the air-intake pipes of the cylinders. The exhaust gases are passed through two double silencers and then through pipes leading under the boilers, from which they are carried off by the boiler stack. The pipe connections between the exhaust ports and the silencers are water-cooled to prevent excessive radiation and heating of the space immediately around the engine heads.

All internal lubrication is supplied by two Bosch lubricating presses operated from the governor shafts. The

piston pins are also lubricated by these. The lubrication of the main bearings and of the crankpin bearings is supplied by a geared lubricating pump, which forces a stream of oil to each bearing, collecting rings preventing any being spilled. The oil is fed to the crankpin bearings by lifting rings. All oil is collected in the crank case, flows through a filter and cooler, and is returned to the main container, located below the floor. The bearings are also provided with individual glass reservoirs and rings for use in case the lubricating-oil pump should fail.

For testing the engine before shipment, 4 tons of Standard Oil Co.'s Richmond fuel oil (a residue) was

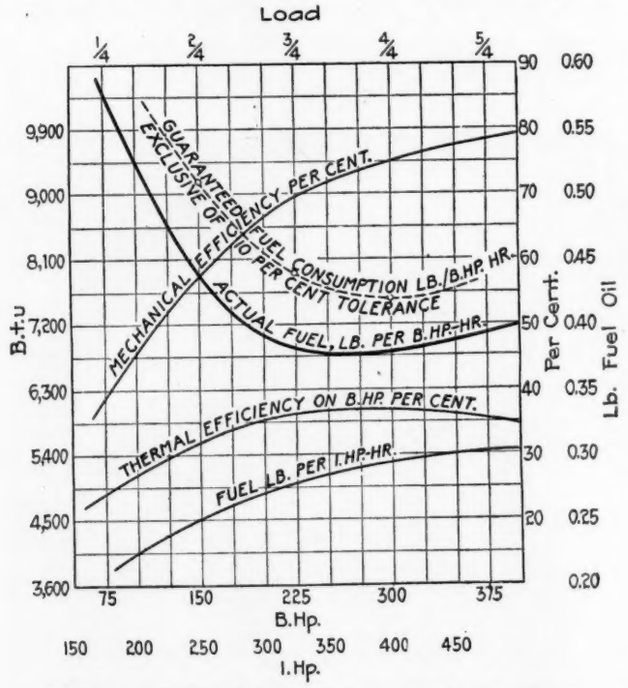


FIG. 3. PERFORMANCE CURVES OF 300-HP., FOUR-CYLINDER KÖRTING-DIESEL ENGINE

shipped to Germany, R. E. Mathot, of Brussels, acted as consulting engineer for the City of Palo Alto, and conducted the tests at the works of the builder. The principal test data are here given, and the engine performance is shown in Fig. 3.

The California fuel oil (Richmond Fuel Oil) had the following properties:

Lower heat value	17,741 B.t.u.
Gravity at 59 deg. F. (15 deg. C.)	0.948
Flash point in open air	185 deg. F.
Boiling analysis—	
Oil begins to boil at	223 deg. C.
Amounts distilled in per cent. of the volume	
at 250 deg. C.	1.5
at 300 deg. C.	12.5
Contents in ash, per cent.	0.01
Contents in coke, per cent.	5.29
Contents in asphaltum, per cent.	1.65
Contents in water, per cent.	0.1
Contents in insoluble matter, per cent.	0.002
Viscosity (Engler) at 20 deg. C.	129.3
at 50 deg. C.	12.9
at 80 deg. C.	3.48
Chemical analysis—	
Carbon, per cent.	86.59
Hydrogen, per cent.	11.47
Oxygen and nitrogen, per cent.	1.33
Sulphur, per cent.	0.61

Note—The oil is very high in constituents, boiling above 300 deg. C., also high in coke.

The guarantees for fuel consumption made by the builders, with a 10 per cent. tolerance in their favor, with oil having a mean lower heat value of 18,000 B.t.u. per lb. per b.hp.-hr., were: At full load, 0.420 lb.; at ¾ load, 0.0440 lb.; and at ½ load, 0.510 lb.

The fuel consumptions determined by test, using the oil with a heat value of 17,741 B.t.u. per lb., were as follows: At full load, 0.388 lb.; at ¾ load, 0.385 lb.; and at ½ load, 0.439 lb.

These figures are lower than those guaranteed, especially if the difference in heat value of the oil used is taken into consideration. Indicator diagrams were taken simultaneously on all four cylinders, also on the low and intermediate pressure stages of the air compressor. The small clearance space in the high-pressure cylinder of the compressor did not permit of attaching an indicator to it. The fuel consumption given includes all work done by the engine and the compressor and represents the net work delivered at the shaft.

Since the engine has been installed and its output has been checked by the output of the generator, the average fuel consumption falls within the guarantee. Some difficulty was at first experienced in finding a cylinder oil which would stand the high temperature in the engine cylinders and compressor. This was met by lowering the cooling-water temperature issuing from the jackets, and principally by experimenting with different oils until one was found that had the desired properties and gave satisfaction. The most gratifying result of the installation is the fact that the predicted saving has been fully realized, the City of Palo Alto saving about $20 daily above its previous practice; and the work of Messrs. J. F. Byxbee and A. V. Youens, representing the City of Palo Alto, is an example of what a progressive municipality under proper guidance can do in furnishing cheap lighting and power service.

Quick-Acting Wrench

The wrench shown has instantaneous adjustment. It is operated by placing the object to be turned between the jaws and pressing the movable jaw in, or drawing it in with the thumb-trigger under the handle, until it strikes the object.

The grip is then maintained and increased by an automatic locking clutch which acts as a cam and has a neutral position that allows the jaw to move freely in and out. The neutral and locking positions are automatic in action.

AUTOMATIC QUICK-ACTING WRENCH

The clutch is made of one piece, and with the mechanical principle involved, the harder the pull on the wrench the tighter is the locking action. A slight pressure on the clutch opens the jaw.

This type of wrench is made in several styles by the Automatic Wrench Manufacturing Co., Boston, Mass.

Mouse Caused Plant Shutdown—Recently a dead mouse was discovered between the terminals of a 2200-volt oil switch connected to a 2000-kw. generator in a small central station in the Middle West. The engineer, while attempting to remove the mouse with a pair of sticks, accidentally got it across two exposed parts of opposite polarity, thereby causing a short-circuit, which severely burned him, destroyed the switch and shut down the plant.

Direct-Current Three-Wire Systems

By Gordon Fox

SYNOPSIS—The different methods of equalizing the voltage on a three-wire system, with special reference to the motor-generator set.

In the majority of plants in which direct current is used there are two competing conditions affecting the selection of the voltage. Economy in wiring for motor service demands the highest voltage consistent with reliability and safety, which is commonly considered to be 230 volts at the generator; whereas the lighting layout usually employs tungsten lamps on a 115-volt circuit. These conditions have led to the extensive adoption of the three-wire system. The 115-volt load will ordinarily be much smaller than the 230-volt load, and the unbalancing of the two sides of the low-voltage system is not likely to be great if care be taken in making the wiring layout.

A number of different means are utilized for obtaining the three-wire service and double voltage. The earliest method is but little used. This employed two separate generators, each wound for 115 volts, placed in series. The two machines combine in carrying the load on the outer wires, while each handles its own 115-volt load. The voltage regulation may be manual or automatic. Perhaps the most common present-day application of this system is that in which a generator having a double commutator is used. The armature is wound with two separate 115-volt windings, each connected to one of the commutators on the opposite ends of the machine. The commutators are connected in series for 230-volt service and their common point supplies the neutral. A machine of this kind is represented in Fig. 1.

The most popular means for providing three-wire service is the so called three-wire generator. This is, ordinarily, a standard 230-volt machine in which the armature is tapped at two or more points 180 electrical degrees apart, the taps being brought out to collector rings. Where the unbalanced load is small two rings will suffice, but if the unbalancing is likely to be considerable it is better to provide four rings and to tap the armature at four points 90 electrical degrees apart, so as to secure a two-phase arrangement. Leads from the collector rings are brought out to a compensator that is merely a reactance coil. An alternating current is collected from the rings and this current magnetizes the reactance coil, inducing a counter voltage such that only a small magnetizing current flows across. The central point of the coil is always the neutral of the system, since it is always half way between symmetrical conductors of opposite polarity. In this manner the half-voltage point is provided. In the case of unbalanced load a direct current passes through the reactance coil and collector rings and part of the armature winding. In a two-phase arrangement the unbalanced load current is distributed over more armature coils, so that heating is more uniform and voltage regulation is better; hence, the preference for this type where unbalancing is likely to be severe. Recently, there have been placed upon the market three-wire generators in which the reactance coil is built into the spider of the armature and the neutral is brought out from the center of this coil by a single collector ring. This makes it possible to tap the armature at more points for a multiphase reactance coil, without the disadvantages of a multiplicity of collector rings.

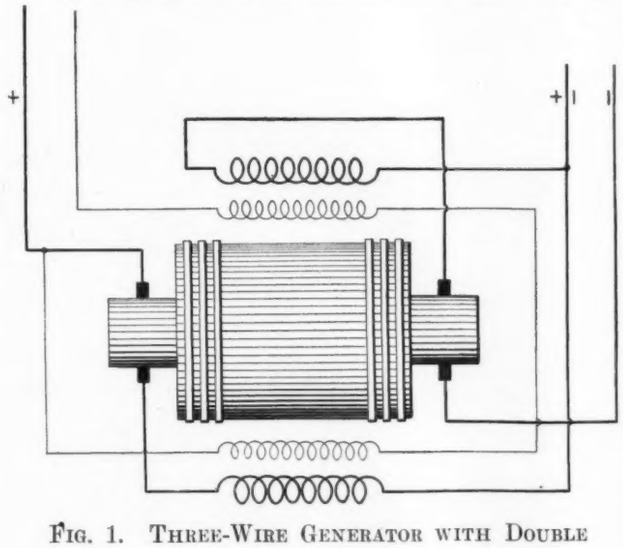


Fig. 1. Three-Wire Generator with Double Commutator

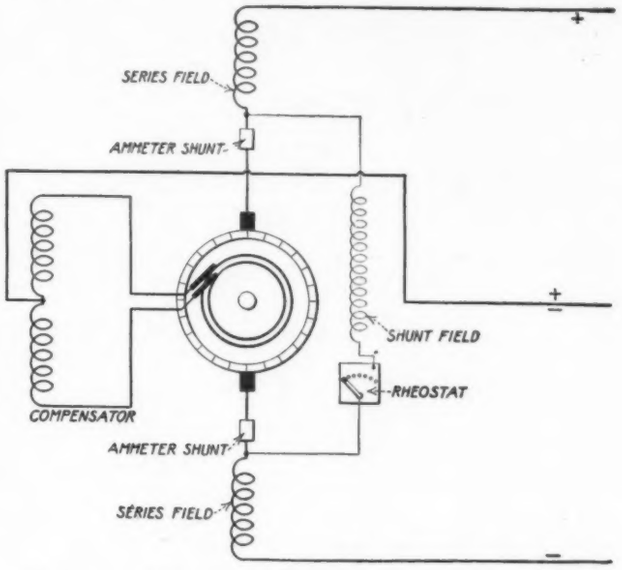


Fig. 2. Connections for Three-Wire Generator

Three-wire generators are commonly designed and rated for 10 per cent. unbalancing, although sometimes a greater amount is specified. These generators may be flat, drooping or overcompounded in their two-wire voltage characteristic, and they will ordinarily maintain the neutral within a 5 per cent. range. Three-wire generators are connected as shown in Fig. 2, the shunt field being connected across the armature and the series field being divided into two sections, one-half in each side of the line. In this manner the compounding effect is averaged for unbalanced conditions. These machines may be operated in parallel the same as two-wire machines. However, there must be two equalizers because of the division of the series field. In adjusting the compounding of three-

wire generators it is necessary to use similar german-silver shunts around each of the series fields, and in proportioning the load division between two machines to operate in parallel it is necessary to adjust the series circuit resistances between both equalizers and busbars instead of just upon one side, as for two-wire machines. When two-wire machines are paralleled the ammeter shunts are placed between the brushes and the series fields to prevent cross-currents from one machine affecting the instruments of the other.

It is possible to provide two-voltage service from a two-wire system by the use of a series of storage batteries connected across the outer lines with the neutral wire connected to the middle point. On balanced load the battery floats across the line. If the load is unbalanced the battery on the heavily loaded side discharges, while that on the lightly loaded side charges. The combined charge and discharge currents flow through the neutral supplying the unbalanced current. The neutral voltage must shift enough to cause this charge and discharge action, so that two combining to feed the extra current to the heavily loaded side. The motor armature carries a current greater than that of the generator armature by an amount sufficient to supply the losses of the set. When the machines are running light their counter electromotive forces are equal and are almost equivalent to the impressed voltage. When an unbalanced load occurs on one side the voltage of that side decreases so that it is less than the electromotive force of the balancer unit, and that side of the set becomes a generator. The voltage across the other unit increases so that its motor action is strengthened and it is enabled to carry the generator load of its mate. It is necessary that an appreciable shift of the neutral occur in order to bring about this change, so that compound balancers are often used in order to secure better voltage regulation.

Shunt-wound balancers having the fields in series or parallel across the outer wires have practically constant excitation for both units. If the central point of the series-connected shunt fields be connected to the service neutral the excitation on the loaded, or generator, side is weakened and that on the motor side is strengthened. This tends to increase the motor electromotive force and

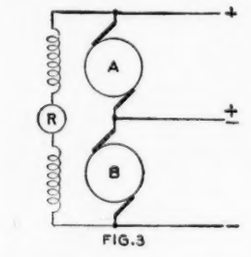


FIG. 3

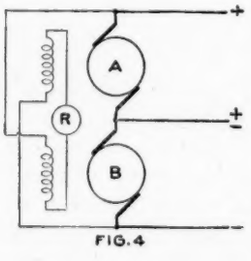


FIG. 4

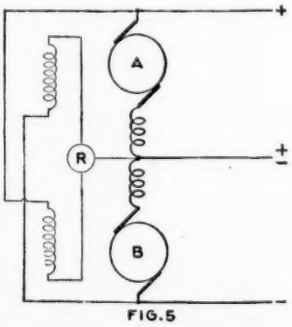


FIG. 5

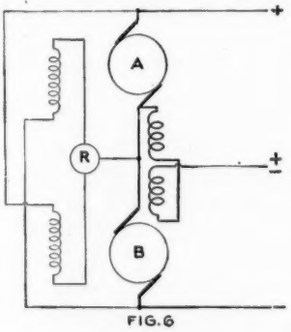


FIG. 6

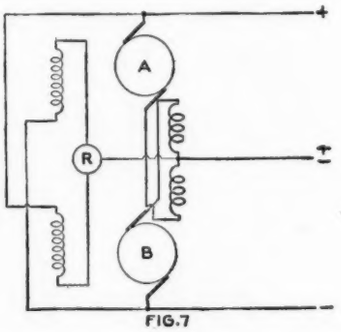


FIG. 7

FIGS. 3 TO 7. DIFFERENT BOOSTER FIELD CONNECTIONS

the regulation is imperfect. The voltage can be adjusted by means of end cells or by the use of a booster.

Double generators or three-wire machines are feasible for plants generating their own power. If only 230-volt power is available and three-wire service is desired, it is necessary to provide a means for locally maintaining the fixed neutral and providing unbalanced current. This is commonly done by the use of some form of balancer. There are several types of such sets, the more common of which will be here discussed.

Motor-generator balancer sets are ordinarily composed of duplicate units direct-coupled and mounted upon a common bedplate. They may be either shunt or compound wound and are sometimes equipped with interpoles. The armatures are wound for half line voltage and are connected in series across the outer leads, their common point being the neutral. The difference in the sets lies mainly in the arrangement of the field connections.

Shunt-wound balancer units may have the fields wound for either half voltage or full voltage. If wound for full voltage the fields are paralleled, and if wound for half voltage the fields may be in series with their central point either connected to the neutral or isolated from it. Fig. 3 shows one connection for a shunt-wound balancer set. With a balanced load both machines run light as motors. With a greater load between the neutral and the positive side, machine *A* acts as a generator and *B* as a motor, the reduce the generator electromotive force. The regulation with this arrangement is therefore poor. If the fields be interchanged as in Fig. 4 the generator electromotive force will be strengthened on the loaded side, tending to maintain the voltage, while the counter electromotive force of the motor is decreased, tending to speed it up, run the generator faster, increase its electromotive force and likewise maintain its voltage. Hence, this connection gives the better voltage regulation.

The action of the compound-wound balancer set (Fig. 5) differs somewhat from the shunt-wound type. Here the series field of the motor side opposes its shunt field, while the series field on the generator side assists its shunt field. Hence, the motor speed is maintained better or is caused to increase, while the generator voltage is likewise built up, tending toward good regulation. With the connection shown in Fig. 5 the series field of the motor carries more current than the series field of the generator, since the motor armature circuit carries the current to supply the losses of the set. The differential action upon the motor is, therefore, strong and the motor is likely to be unstable and to race under heavy loads.

The arrangement shown in Fig. 6 causes both series fields to carry the same unbalanced current, thereby improving stability. That of Fig. 7, in which the series fields are interchanged, places the generator series field in the motor circuit and *vice versa*. Since the motor arm-

ature current is greater than the generator armature current, the cumulative action of the generator field carrying motor current is stronger than the differential action of the motor series field carrying generator current. The excess of compounding is shifted from the motor to the generator, the rise in speed under load is decreased, there is less tendency to instability, and the voltage regulation is improved.

The units composing a balancer set act alternately as motor and generator. Therefore, the brushes must be set in a central position corresponding to no-load neutral. The neutral of a generator shifts in a direction with the rotation, while that of a motor shifts against the rotation. The brushes, therefore, cannot be located properly for both conditions. Since the motor end carries the greater load, it is well to give the brushes a slight motor lead to favor this mode of operation. It is a characteristic of the interpole motor or generator that the neutral remains fixed for all loads. Therefore, the condition of interchangeability can well be met with interpole machines and one position of the brushes will be correct for all operating conditions. Without interpoles commutation is a limiting feature and the units must be rated low to prevent sparking under load with the brushes set at a compromise position. The tendency to instability is somewhat greater for interpole sets than for those without these poles. The fact that the brushes of noninterpole machines are behind the full-load neutral as a motor, tends to hold down the load speed. In the interpole machine this effect is removed and the general tendency to maintain speed under load and to race is sometimes evidenced. The interpoles of balancer sets may require shunting with german silver, the same as is done with ordinary interpole motors.

The stability of compound-wound sets depends to some extent upon the degree of compounding. Balancers are ordinarily flat compounded or are adjusted for this degree of compounding by means of german-silver resistance shunted across their series fields. If a balancer set is connected to long feeders it may be desirable to overcompound to compensate for drop in the feeders. About 5 per cent. overcompounding is as much as can be safely provided in most sets.

Balancer sets are started with the shunt fields connected directly across the outer lines, with the center point disconnected from the neutral. The two armatures are connected in series through a starting box and are brought up to speed without load. The central point of the fields is then connected to the neutral of the set, and the voltage is adjusted for equal division. Then the neutral of the set is connected to the service neutral, and the unit is in operation.

Balancer sets may be successfully operated in parallel, but careful adjustment is necessary to secure even voltage regulation and proper load division. The units must be connected in the same manner, so that their relative speed and voltage-regulation characteristics will correspond. If the units are compound-wound one or more equalizers are necessary. If the fields are connected in series in the neutral line, as in Fig. 6, one equalizer will suffice. If they are connected as in Figs. 5 or 7 two equalizers will be required. Care must be taken to see that the equalizers connect corresponding points. The series fields should be connected on the inside next to the neutrals, as shown; if connected outside and the units were paralleled, there would be cross-currents through the equalizers into the leads to the line wires. Since the machine ammeters, fuses or circuit-breakers are connected in these leads, it is desirable that only the current for the unit protected should be able to traverse this circuit. In paralleling balancer sets the same rules hold as in paralleling any direct-current generators. If the series field circuits between the equalizers and the neutral do not have resistances inversely proportional to the machine ratings, then it is necessary to insert german-silver resistances in the series field circuit of that unit in which the resistance is proportionately low.

Adjustments

There are a number of adjustments possible upon balancer sets. Consider the case of two compound-wound interpole sets that are to be adjusted to regulate properly and to run in parallel. First, the brushes of one end of one set should be located upon neutral by running that end as a motor upon half voltage and shifting the brushes until the speed of rotation is the same in both directions running light. This procedure is then repeated for the other end of the set. Next, connect one end as a motor and the other end as a generator, separately. Connect the shunt fields as they will be connected in service. Load the generator end and note the voltage and speed regulation. If the voltage regulation is not flat (assuming that flat compounding is desired) then shunt both series fields with similar german-silver shunts and adjust the shunts until the desired result is approximately obtained. If violent sparking or racing occurs it may be necessary to shunt the interpoles also. The correct interpole shunt is best found by using a low-reading voltmeter and "exploring leads" which bridge from segment to segment of the commutator and indicate the position of no voltage between bars. When the interpole is of the correct strength the neutral will be at the same point both at no load and full load.

With these preliminary adjustments made, the set may be tried out as a balancer. The rheostats should be set for equal voltage division at no load. Then full unbalanced load may be thrown first on one side and then on the other and the voltage regulation noted. If it is not exactly as desired a slight adjustment of the german-silver shunts may be necessary. Possibly, one method of connection will be found to give more satisfactory results than another. Both sets having been thus adjusted and tried out singly, they may then be tried for parallel operation. If they fail to divide their load properly it may be necessary to insert german-silver resistance in the series field circuits of one of the units.

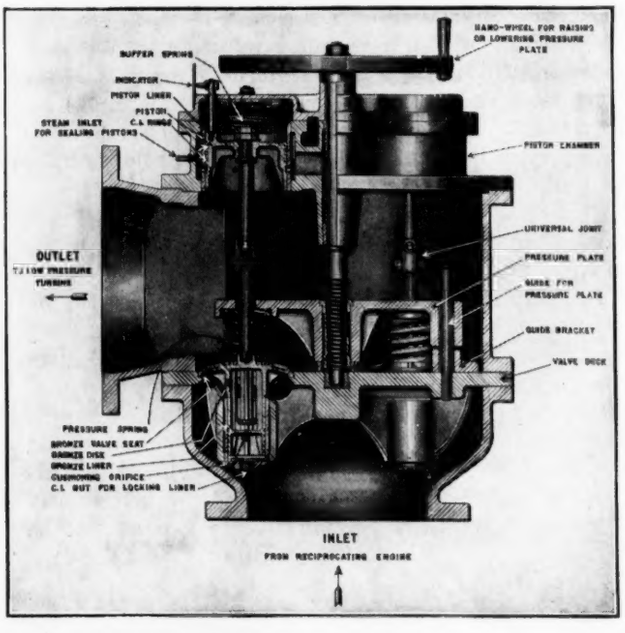
The method of protecting balancer sets depends upon the importance of uninterrupted service and the delicacy of the connected load with voltage change. Lamps are more susceptible to injury through excessive voltage than are motors. Fuses are quite frequently used in the line leads of balancer sets. A circuit-breaker in the neutral operating the circuit-breaker in the main lines by means of a trip coil will cause severance of power when excessive unbalanced load occurs, or a differential voltage relay may be used to trip the line circuit-breaker when excessive voltage inequality occurs.

The required rating of balancing equipment compared to the connected load depends largely upon local conditions. One side of a building may be dark while another

side is light, or lights may be required in the central portion of a room when not necessary near the windows. Many causes contribute to unbalancing, and the amount as compared to the load is rather difficult to determine. It is desirable to maintain the unbalanced load in any system as low as possible. For this purpose throw-over switches are sometimes provided, which make it possible to transfer one or two two-wire circuits from one side of the system to the other to maintain an approximately balanced condition. Where this is not done it may be possible to connect over some of the circuits from one side of the system to the other to secure a better average balance. Sometimes, three-wire switchboards for distribution circuits are arranged to make interchange and rearrangement of circuits easy, so that balanced conditions may be maintained even though circuits are added or modified. Balancers are most frequently installed capable of handling 10 per cent. unbalanced load, that is, a load of one-tenth of the connected load all on one side of the line. Balancer units must each have a capacity equal to one-half of the rated unbalanced power, plus the losses of the set.

Cochrane Multiport Flow Valve

Among the various types of multiport valves built by the Harrison Safety Boiler Works, at 17th St. and Allegheny Ave., Philadelphia, Penn., is the multiport flow valve for use with mixed-flow turbines. Its purpose is to close communication between the exhaust line from the engine and that stage of the turbine to which the exhaust steam is admitted, whenever the pressure in the latter falls below atmospheric.



MULTIPORT FLOW VALVE IN SECTION

In performing this function a vacuum is prevented in the engine exhaust pipe, the presence of which would result in the infiltration of air through leaks and past piston-rod and valve-stem packing, which would result in an overburdened condenser air pump.

In preventing the formation of a vacuum the draining of the receiver oil separator is not interfered with; this also applies to the oil separators on heaters and receivers in the engine exhaust line.

When a mixed-pressure turbine, one which receives steam at two different pressures, usually live steam and exhaust at about one or two pounds above atmosphere, is equipped with this flow valve, the exhaust steam is automatically cut off as soon as the pressure in the exhaust line approaches a predetermined maximum, say one pound above atmospheric. This action causes the flow of exhaust steam to back up and maintain a pressure in the exhaust-steam main, live steam being used by the turbine during the period the valve is closed. As soon as the exhaust-steam pressure builds up above the predetermined point the flow valves open and the live steam is cut out by the action of the governor.

The construction of the valve is shown herewith. Each valve disk is connected to and balanced by a piston of the same area. As the pressure in the turbine intermediate inlet acts on the top of the valve disk and on the under side of the balanced piston, it has no effect so long as the disk is closed. The pressure of the engine exhaust acting on the lower side of the valve disk is opposed by the pressure of the atmosphere acting on the upper side of the balanced piston. Whenever the pressure in the engine exhaust line exceeds the atmospheric a certain amount, determined by the tension of the spring pressing on the upper side of the disk, the valve opens wide, because as soon as it leaves its seat the pressure on the two sides of the balanced piston forces it out against the spring. Striking of the piston is prevented by buffer springs. When the pressure in the turbine inlet opening drops near to atmospheric pressure it, reinforced by the spring, forces the disk to its seat.

The valve thus prevents steam from flowing from the engine exhaust line to the turbine unless the absolute pressure in the former exceeds a certain minimum. As the balanced pistons are steam-sealed, no air is admitted by them.

A Cheap Covering for Steam Pipes

A nonconducting coating for low-pressure steam pipes and the like, used for the past ten years with perfect satisfaction by a Boulogne engineering firm, is described in a recent issue of the "Revue Industrielle" as being conveniently applied and cheap, while it can be prepared by any steam user. It consists of a mixture of wood sawdust with common starch, used in a state of thick paste. If the surfaces to be covered are well cleaned from all trace of grease, the adherence of the paste is perfect for either cast or wrought iron. For copper pipes there should be used a priming coat or two of potter's clay, mixed thin with water and laid on with a brush.

The sawdust is sifted to remove too large pieces, and mixed with very thin starch. A mixture of two parts of wheat starch with one part of rye starch is the best for this purpose. It is the common practice to wind string spirally round the pipes to be treated, keeping the spirals ½ in. apart to secure adhesion to the first coat, which is about ¼ in. thick. When this is set, a second and third coat are successively applied, and so on until required thickness is attained. When it is all dry, two or three coats of coal tar applied with a brush will protect it from the weather.

California's Crude-Oil Production in 1914 was 103,623,695 bbl., against 97,867,148 bbl. in 1913.

Water Power in Switzerland is conserved and utilized to such an extent that in some towns not an ounce of coal is used. Power, light and heat are furnished by water power.

Safety Valves--A Discussion

By A. B. Carhart*

SYNOPSIS—Discusses a paper read by Donald MacNicoll before the Institution of Engineers and Shipbuilders, Scotland. This paper dealt chiefly with a special safety valve in which the passage through the seat is nearly equal to the full inlet area; the main or relief valve is not spring-loaded, but is controlled by the action of a pilot valve. The reviewer shows that this, as well as other ideas, is old, and that valves so constructed have never been successful. In America since 1860 only two principles of construction have proved mechanically satisfactory. Foreign practice compared with our own.

It was before the Institution of Engineers and Shipbuilders in Scotland that Hazleton R. Robson presented his paper in 1873 demonstrating the advantage of springs instead of dead weights and levers for loading safety valves. This was several years after spring-loaded pop safety valves had been introduced into this country.

Recently Donald MacNicoll, of Cockburns, Limited, Glasgow, read a paper on safety-valve design before that society, the paper dealing chiefly with tests of some special "full-bore" safety valves recently applied to boilers of destroyers in the British Navy. The interesting feature in these valves is that the passage through the seat is practically equal to the full area of the inlet. But the main relief valve is not spring-loaded and proportioned to give automatic opening and closing, to make the amount of blow-down in pressure adjustable, but is in effect simply an adaption of the "compound" whistle valve commonly used in this country, having a steam piston whose operation is controlled by the action of an auxiliary pilot valve. This idea is not new, for other valves operating upon the same principle have been patented in Great Britain and in this country; and as long ago as 1874 Thomas Adams read a paper before the same society, in Glasgow, describing a relay type of safety valve patented by him, in which the opening of the main relief valve was controlled in similar manner by the action of a much smaller valve. But none of these valves has ever been commercially successful, and Mr. MacNicoll's paper indicates that mechanical difficulties have been encountered in the latest type, and that much must still be accomplished before it is as satisfactory as the safety valves commonly used in this country. For example, he says: "All the valves lift at about 7 lb. above the working pressure, drop or close on their seats at the working pressure, and are absolutely tight at not more than 7 lb. below the latter."

Mr. MacNicoll's paper is interesting, but much of the work he refers to has already been done in this country, and much, if not all, that he describes as the latest endeavors in such experimental work in Great Britain, is shown in various American patents issued twenty-five to forty years ago.

The safety valves commonly used in Great Britain are not of the type so familiar here. Instead of having the "pop" feature, most of them are valves without any expansion chamber at the lip to give full initial lift, and which depend upon long and flexible springs to permit sufficient opening at the seat. But although many in this country know that the safety valves used abroad do not afford as much relief in steam discharge as pop safety valves, it is interesting to find the corroboration of this in Mr. MacNicoll's paper. Of safety valves commonly made there, he says:

> In connection with the Board of Trade type of valve, the accumulation allowance or the amount of excess pressure over the working pressure, when all stop valves and feed-check valves are shut and the specified amount of coal being burnt, must not exceed 10 per cent. of the working pressure. The Admiralty allowance is 7 per cent., but with the feed maintained; this latter, of course, is essential for water-tube boilers. In most cases, with Board of Trade valves it has been found that when the working pressure exceeds 210 lb. by gage, this allowance is exceeded.

Mr. MacNicoll says that a possible explanation of this undue rise in pressure, indicating insufficient valve-discharge capacity, lies in an insufficient escape-pipe area, resulting in a throttling of the escaping steam, causing back pressure on the valves and preventing them from lifting properly.

> This pressure has gone up as high as 40 lb., whereas it should never be more than about 15. . . . . It has been suggested that in certain cases an accumulation test has been stopped, owing to the accumulation having got considerably beyond the allowance, and was still rising, the surveyor knowing at the same time that he was not justified in condemning the valves, as the area was correct and compression of spring in order, according to the Board of Trade formula. It would appear in cases of this sort that the valve had not enough lifting effort.

Concerning the lifts of such valves, he says:

> It must be remembered, however, that American safety valves have very different fittings from those manufactured in this country. The rigid type of spring adopted in the former giving less than ⅛ the diameter of the valve for initial compression, necessitates a carefully designed seat and plate on the lid to lift the valve sufficiently. . . . . The short rigid spring is noticeable when compared with the present British Board of Trade type. . . . . Since the introduction of the spring-loaded Board of Trade type of valve, the design has altered but little. . . . . It should be set to lift at from 5 to 7 lb. above the working pressure, and when properly constructed should drop on its seat at about the working pressure. The compression of the spring at the blowoff pressure should be ¼ the diameter of the valve.

He describes also the Admiralty type of spring-loaded safety valve, in which "the specified initial compression of the springs is equal to the diameter of the valve, or four times the elasticity of the Board of Trade springs." Even the great length of the springs, 11½ or 13 coils, or more, is not sufficient to insure proper lifting of the valves to afford free steam discharge, as is further evidenced by Mr. MacNicoll's quotation from a report of the trial, made some five or six years ago, of an experimental type of valve:

> The ordinary spring-loaded safety valve is usually big enough to take away all the steam that an ordinary boiler can generate under ordinary firing conditions. Certain peculiarities are inherent, but seem to have become accepted with resignation by engineers. For instance, the lift is usually indequate, owing to pressure accumulating above the valves, and acting downward on the larger area provided by the lip. . . . . When the valves lift, the rush of steam past the lip prevents the valve closing until the pressure in the boiler has fallen considerably below the working pressure. This is known as "drop," and may amount to as much as 10 per cent. of the working pressure. It is usually looked upon as inevitable, but is a serious matter on a full-power trial where the loss

*Superintendent, Crosby Steam Gage & Valve Co.

of water is measured and where it is important to maintain full boiler pressure over a long period, hence the practice of having a man told off to watch if any valve lifts, and to at once tap it down again on to its seat.

Concerning the lift of safety valves, he comments upon the experiments made a few years ago, and says:

Although the balance-disk valve was not considered satisfactory, it was agreed that a valve giving a greater lift than the ordinary type was desirable. The ordinary type of valve lifts about $\frac{1}{24}$ of its diameter, while the Gibson valve lifted $\frac{1}{8}$.

Referring to the experiments made in 1874, he says:

It is suggested that with a specially designed Cockburn valve it reached the full amount—namely, ¼ of the diameter—but this is not likely, and certainly a rule proposed by the committee allowed for a lift of only $\frac{1}{36}$ of the diameter.

This would seem to indicate that foreign safety valves, in spite of the long springs, do not have the excessive lifts with which they are sometimes credited in discussions of the subject. The duty under our present tariff is not high enough to prevent the importation of safety valves from abroad if they were desired. Some manufacturers in this country are often called upon to duplicate such valves for marine boilers in special cases, but even this intimate knowledge of their construction has not led to their general introduction here. One statement made by Mr. MacNicoll concerning some of the valves tested, using large springs made according to the Admiralty rule, indicates that the long springs have disadvantages that might develop into exaggerated difficulties under American conditions of service:

In torpedo-boat-destroyer work also, the large springs had been found to be a source of trouble; excessive vibration keeping the springs continually on the dance, and serious leakage consequently ensuing.

Mr. MacNicoll describes the experiments of J. H. Gibson, of the firm of builders of the British torpedo boat destroyer "Cossack," which was one of the first vessels burning oil fuel in which serious difficulty was experienced with the ordinary Admiralty safety valves:

During the accumulation trial the steam pressure rose to a dangerous extent with the pointer of the gage going up rapidly. To prevent an accident the easing gear was applied. It was observed that it required only a very small additional lift to the valves, somewhere about $\frac{1}{64}$ in., to keep the accumulation within the specified amount. . . . . While the new valves were being manufactured, he carried out an experiment on one of the original valves. A small steam cylinder fitted with a piston was attached to the boiler shell in the vicinity of the safety valve. The piston was attached to the easing gear in such a manner that on the piston moving outward the valves were eased. The bottom of the cylinder was connected with the waste-steam space of the safety valve. The effect was that the excessive pressure in the waste-steam space assisted the valves to lift instead of preventing them from doing so.

This experimental valve was described, at the time, in *Engineering* (London), Feb. 26, 1909, and mentioned by the writer in an article in POWER, Mar. 23, 1909. The comment is made that "the trials were most satisfactory," but subsequent events cast doubt upon this conclusion. It is apparent that only one such valve was ever made; and the idea of utilizing the excessive back-pressure in operating a lever to overcome its harmful effects seems too much like lifting one's self by the boot-straps. In the torpedo boat destroyer "Swift," constructed later by the same firm, each safety valve, "instead of having an external cylinder as previously mentioned, was fitted with a balancing piston, or disk, which neutralized the effect of back-pressure in the valve casing." This device was sufficient to overcome the difficulty with the safety valves, as far as the accumulation allowance under test was concerned.

But this idea also, of a larger disk fixed to the valve spindle, is not new, for it is shown in many of the older patents. A somewhat similar scheme for using the back-pressure to give extra lift to the valve was an important feature in the old "Crosby-Meady" muffled locomotive pop valve of 1885, that showed lift of ¼ in. This had a considerable sale thirty years ago. In justification of such a device, the report upon the tests of these experimental valves says:

To obviate the objectionable action of this pressure [the back pressure in the valve casing] and, if possible, to make it perform useful work is the object of this invention. By making the balancing disk equal in effective area to the valve, the effect of the fluctuating pressure in the valve box is eliminated, and the valve lifts gradually and quietly to the full amount permitted by the compression of the spring, and the allowable accumulation. . . . . The removal of the lips from the valve and seat steadies the action of the valve, and prevents "beating" or "chattering," thus increasing its life or period of steam-tightness.

"Gradually and quietly" in the original report emphasize the desirability, sometimes too little appreciated, of the practical advantages of smooth and quiet operation of a boiler safety valve, as compared with the sudden and violent explosiveness that sometimes results from an effort to obtain an excessive rate of discharge or an instantaneous relief. However, it is evident that the desired results were not fully realized, for Mr. MacNicoll says:

Subsequently, Messrs. Cockburns made valves of this type, but it is regretted that while amply meeting with accumulation conditions, the question of when the valves commenced to lift and when they shut off tight was a most vexed one. With the ordinary type of valve the lift is definite—a distinct "pop" is heard, although simmering may have taken place for some time previously. With the balance-disk type the first slight feather at the waste-steam pipe was taken as the commencement of lift, this gradually increasing till the valves were blowing full; the range of pressure every time the valves lifted was about 30 lb. per square inch. Similarly, on the valves closing again the range was 35 or 40 lb. per square inch. These valves were refitted repeatedly, with no betterment.

Mr. MacNicoll describes the difficulty they had with continued leakage at the valve seat (attributed to distortion of the seats of the valves, which were 3½-in. size) and mentions the improvement in the behavior of the valves after they were fitted with a different type of disk, but makes the significant statement:

After this they never gave satisfaction, and about 18 months thereafter were replaced. Subsequently, it was found that this type of valve had been used in the United States for a considerable time.

The next form of experimental valve tried was upon the same principle, but had a much larger piston fitted above the valve disk, so that back pressure in the body would force the disk further from its seat. It does not seem logical to have developed this idea so far; for the real purpose of any safety valve employed should have been to discharge the escaping steam, for the relief of the boiler, rather than to throttle the discharge pipe to gain more lifting power inside the valve body. For of what use is it to gain greater lift and larger opening at the valve seat if free discharge of the steam from the valve casing is not permitted? This valve appears to have been inoperative except under special conditions. To again quote Mr. MacNicoll:

The piston was made considerably larger than the valve, and a stop valve was fitted to the outlet as shown, so as to maintain any desired pressure in the waste-steam space. This valve could be made to give a lift of ¼ of its diameter under favorable conditions, but was found to be somewhat erratic in its action, and the slightest increase to the lift on the stop valve from that which allowed of full lift to occur in the safety valve prevented the latter from lifting more

than a very small amount. The drop also was very inconstant —generally the valve was considered unsatisfactory.

As an alternative device, intended as an improvement upon the experiments described, a compound valve was devised, in which the opening of a small spring-loaded pilot valve allowed the steam behind a piston of larger area to force open a main relief valve against the boiler pressure.

Such valves are interesting in principle, but have been described in early U. S. patents; for example, in the patents to Shepard in 1873, to Anderson in 1877, and to Scovell in 1879, as well as in that to Collier in 1882. Many variations in the mechanical embodiment of the same idea have been tried, but have never been able to displace the familiar automatic safety valve of the "pop" type. In the discussion of Mr. MacNicoll's paper, R. A. McLaren stated that he had designed a valve on much the same principle between twenty and twenty-five years ago.

George W. Richardson, the inventor of one of the early successful American safety valves, was granted his first patent in 1866, and this was followed by another in 1869, the papers of which describe the adjustable ring for regulating the amount of blowdown in boiler pressure. Among the numerous safety valves shown in United States patents since 1860, only two fundamental principles of construction have proven mechanically satisfactory. These are Richardson's idea of an overhanging lip and stricture ring, forming an adjustable "huddling chamber" surrounding the valve seat, and Crosby's opposite plan of using a flat, double seat and controlling the blow-down by regulation of the small part of the discharge that is bypassed through a central chamber beneath the disk, instead of at the valve seat. All the later commercially successful improvements have been based upon the ideas of one or the other of these two pioneers.

One difficulty met with in the designing of any spring-loaded pop safety valve that is to be self-regulating and automatic in operation, is the limitation upon the amount of spring compression and lift of the valve that can be easily attained without sacrifice of some of the desirable characteristics of such valves. Therefore, the devising of other forms of boiler relief valves has been a favorite field for inventors' schemes. Even during the discussion of Mr. Robson's original paper before the Institution in Glasgow in 1873, David Rowan remarked: "When we have a safety valve which will lift one-fourth of its diameter, or to give an area equal to the diameter of the valve, then the question will be put on a scientific basis." This underlying idea has persisted ever since, and is rediscovered in turn by each one who gives original thought to the subject. This is doubtless the reason why so many have experimented with various forms of balanced-piston and relay valves, which apparently would give "full opening" for boiler relief.

A reliable automatic safety valve must do more than merely discharge steam. In fact, the opening of a relief valve to give "full discharge" is one of the simplest details in the problem, and easiest of solution. Even Mr. Rowan, back in 1873, said that it "could easily be done." The greatest difficulty arises in getting the valve closed again. The wide range of blow-down commonly accepted in foreign practice, or in the operation of valves on marine boilers, would not be countenanced by operating engineers in this country, after their experience with modern pop safety valves.

Comments appearing incidentally in Mr. MacNicoll's paper are especially interesting as indicating that some of the safety-valve specifications appearing in the new A. S. M. E. Code are wise and proper. For example, he emphasizes the lesson drawn from some of the safety-valve experiments, that discharge piping of ample size must be provided for carrying away the exhaust steam from the safety valve. In connection with the subject of springs for safety valves he says:

There appears to be a broad rule, however, for determining a safe spring—that is, one which will remain for any length of time under a load with the coils almost touching, maintain this compression, and resume its free length when the load is removed.

The recently approved specifications of the A. S. M. E. on this subject are intended to accomplish this to insure that springs used in safety valves shall not under any circumstances take any permanent set.

After describing in detail the construction and method of operation of the piston type of valves in the latest experiments, Mr. MacNicoll comments:

If they are placed near the top of the boiler and have easy leads in the waste-steam pipe, no vibration or movement will take place. If, however, they are fitted with internal pipes there is a tendency to vibration; apart from this, internal pipes are most dangerous when fitted to safety valves, and serve no useful purpose.

This seems to be further confirmation of the wisdom of the provision in the A. S. M. E. Code that safety valves shall be connected directly to the shell of the boiler.

There has been some discussion concerning the most practicable method of calculating the total boiler evaporation for which safety valves should be provided, and upon this point one comment of Mr. MacNicoll's is pertinent:

With the advent of oil fuel in the Navy, the size of safety valves based on a formula taking coal as a factor proved altogether inadequate. It appears somewhat singular that the formulas for arriving at the size of safety valves, in the case of the Board of Trade rule, should be derived from area of fire grate and steam pressure, and in connection with the Admiralty, from heating surface and steam pressure. One would have thought the factors necessarily presenting themselves would have been evaporation and steam pressure. . . . .

Turning to the rule formulated by the Board of Trade, it appears somewhat strange that they should have decided on a rule which gives a "disk area" and not a "clear area" for the escape of steam. . . . . As already stated, it now appears that it would have been better had the Board of Trade rule settled the actual area for discharge. During the experiments by the committee it was found that the lift was variable.

The Horsepower of a Cannon

A matter of speculation likely to interest engineers is the enormous energy or horsepower developed in the breech of a big modern cannon discharging a projectile weighing, say 1850 lb., at a velocity of 2000 ft. per sec., when

$W = 1850$ lb.;
$V = 2000$ ft.;
$g = 32.16$.

The formula

$$E = \frac{WV^2}{2g}$$

gives 110,000,000 ft.-lb.

This amount of work must be accomplished during the projectile's travel in the gun, probably not over $^1/_{100}$ of a second. Therefore,

$$\frac{110{,}000{,}000 \times 100}{550} = 20{,}000{,}000\ hp.$$

or in another way, the vertical distance a body would have

to fall to attain a velocity of 2000 ft. per sec. at a uniform rate of acceleration due to gravity would be about 60,000 ft. A projectile weighing 1850 lb., falling this distance would generate

$$1850 \times 60{,}000 = 111{,}000{,}000 \textit{ ft.-lb. of energy.}$$

The same amount of energy would be required to produce the same velocity at the muzzle of a cannon and represent in horsepower

$$111{,}000{,}000 \div 550 = 200{,}000+ \textit{ hp.}$$

if done in one second; but the actual time is probably about as the length of the gun is to the velocity, or 20 to 2000, or $^1/_{100}$ of a second. The energy exerted for the shorter period must be 100 times greater, or equal to 20,000,000 hp.

Foster Automatic Feed-Water Regulator

The Foster automatic feed-water regulator is designed to maintain water at the predetermined height. Normally, the water in the boiler or water column seals the end of the pipe leading to the top of the expansion tube, so that steam is excluded therefrom and the tube is cool or contracted. In this condition of the expansion tube the long arm of the bell-crank lever *A*, Fig. 1, is free to swing outward and allows the weight to depress the arm of the lower bell crank *B*, so as to slide the valve *C* downward into a closed position, cutting off and preventing water from entering the boiler through the feed line.

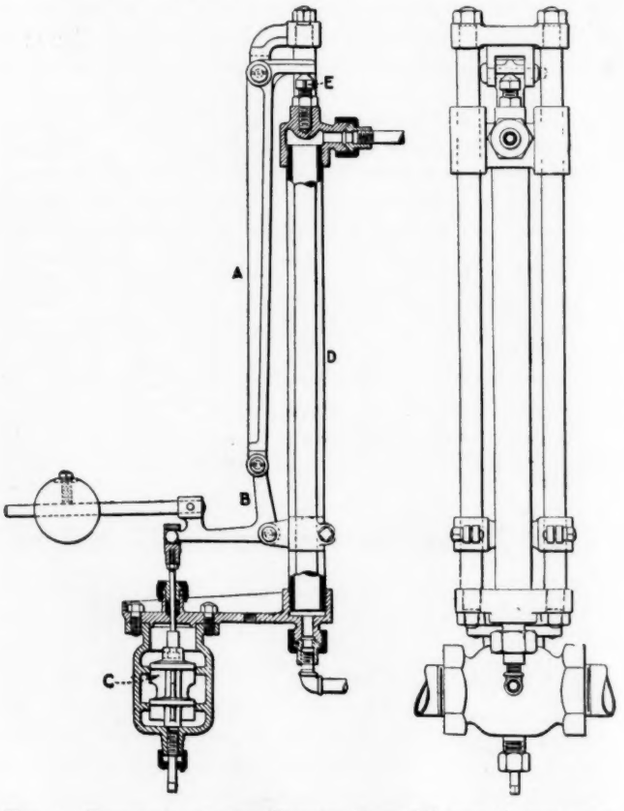


FIG. 1. DETAILS OF THE FOSTER FEED-WATER REGULATOR

When the water recedes below the predetermined level, it uncovers the opening in the pipe leading from the water column to the top of the expansion tube and permits steam to enter it. This heats and expands tube *D*, carrying the adjusting screw *E*, which can be set for any desired variation, upward against the short arm of the bell-crank lever *A*, thus swinging the long arm of the latter inward or toward the expansion tube. This carries the lower bell-crank lever *B* and raises the weight, drawing the valve *C* upward, opening the main feed valve, and permitting water to flow through the feed pipe into the boiler. The flow continues until steam is again cut off from the expansion tube *D*, allowing the latter to contract sufficiently to close the valve *C*. Fig. 2 shows the regulator and pump connections. This regulator is manufactured by the Foster Engineering Co., 119 Monroe St., Newark, N. J.

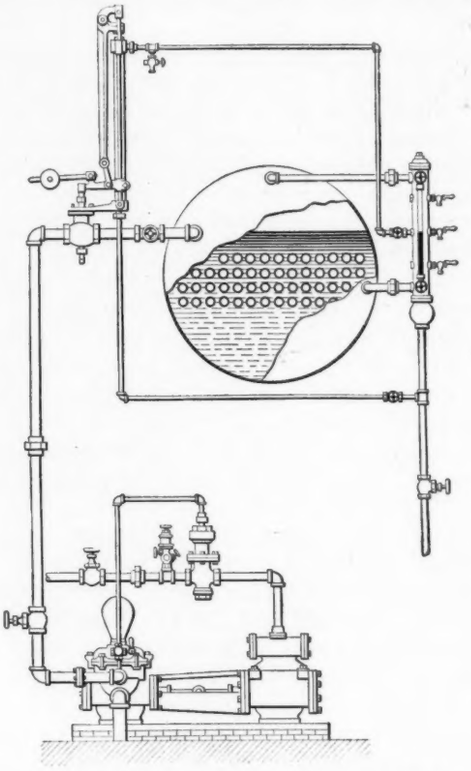


FIG. 2. REGULATOR AND CONNECTIONS

Rules for Properties of Copper and Brass Pipes

The British Board of Trade rule for the thickness of brazed copper steam pipes is

$$T = \frac{D \times P}{6000} - \frac{1}{16}$$

in which

T = Thickness of plate in fractions of an inch;
D = Diameter of pipe in inches;
P = Working pressure in pounds per square inch.

For working pressure of brazed copper steam pipes,

$$P = \frac{6000 \times (T + \frac{1}{16})}{D}$$

To find the weight of copper pipes,

$$W = 3.03\ (D^2 - d^2);\ \text{or}\ 3.03\ (D + d) \times (D - d)$$

in which

W = Weight per lineal foot of pipe in pounds;
D = External diameter of pipe in inches;
d = Internal diameter of pipe in inches;
3.03 = A constant.

To find the weight of brass pipes per lineal foot,

$$W = 2.82\ (D^2 - d^2);\ \text{or}\ 2.82\ (D + d) \times (D - d)$$

in which

W = Weight of pipe per lineal foot in pounds;
D = External diameter of pipe in inches;
d = Internal diameter of pipe in inches;
2.82 = A constant.

Editorials

License Laws in Massachusetts

There have been ructions in the good old Commonwealth of Massachusetts for the past few weeks. A powerfully organized attack has been made upon the existing law by the employers, who complain that it contains, in addition to its provisions for safety, features that impose unnecessary hardships upon the employees and useless burden upon the manufacturers; that it recognizes no difference in the risk of operation between steam engines and steam boilers; that it fails to limit the scope of examinations and permits the requirement of knowledge of the principles of design in the examination of applicants for license to operate, of a knowledge of the principles of boiler design in an examination for a permit to operate engines, and permits the examiner to require involved mathematical calculation, thereby denying employment to competent men.

There have been, for a long time, evidences of friction between the employing and the laboring interests, over the interpretation and administration of the law. Shall a single licensed man in responsible charge suffice for a plant, or shall everybody, down to the coalpasser, be required to have a license?

Shall the examiner simply satisfy himself that a man knows enough to keep water in the boiler and the safety valve clear, or shall he assure himself, broadly, of a man's ability as an engineer and of his general understanding of the principles of and of his familiarity with, the apparatus involved, in the processes of the oversight of which he seeks responsible charge?

Shall an inspector fearlessly and impartially enforce the provisions of the law and the Code, or must he handle friends of the appointing powers with particular consideration to hold his job?

Stories are told of an inspector who made seventy-three arrests and got seventy-two convictions, whose pernicious activity was checked by laying him off for three months "for using language unbecoming an official." On the other hand, it is maintained that the inspectors appointed by the District Police do not all know too much about boilers themselves.

The manufacturers, therefore, had a bill, known as House Bill No. 1111, introduced, which provided that with every licensed person employed there may be one unlicensed person employed, who, in the presence and under the personal direction of the licensed person, might operate steam boilers and their appurtenances; defined what was meant by "control," "operation," "have charge of," etc., as used in signifying where licensed men were required, etc. The bill also required a different examination and license for a man who was to have charge of engines than for one who was to have charge of boilers, and provided a practical examination for both, with the privilege of having present an observer who might take notes.

This bill met with strenuous opposition from the engineers, and on Mar. 22 the Governor addressed a message to the Legislature, in the course of which he said:

As you are doubtless aware, there has been for some years a serious controversy between the representatives of organized labor and the representatives of the manufacturing interests, in regard to some of the provisions of the existing law relative to engineers' and firemen's licenses and in regard to the enforcement of law by the Boiler Inspection Department of the District Police. I am informed that after repeated conferences and long discussions these differences have now been amicably adjusted and an agreement reached whereby the opposition of organized labor to House Bill No. 1111, amending the law regarding engineers' and firemen's licenses, is withdrawn and the support of the manufacturers to the bill herewith transmitted is accorded.

The bill "herewith transmitted" takes the inspection of boilers and the examination of engineers entirely out of the hands of the District Police and establishes a Bureau of Steam Engineering and Inspection to take care of it. Bill No. 1111 was withdrawn by mutual consent of a committee composed of engineers and manufacturers, and in its place another bill has been drawn up, amending the present law so as to overcome the objections of the manufacturers without prejudice to the engineer.

New Methods of Producing Gasoline

Widespread interest has been created within the past few weeks by reports in the daily press of discoveries calculated to greatly increase the supply of gasoline, besides making available benzol and toluol, which heretofore have been produced from coal tar. The toluol is an important ingredient in modern high explosives. First came the announcement of Dr. Snelling's process, to be followed closely by that of Dr. Rittman, and finally the information that Edison had started a plant for the production of benzol and a number of residual products, ordinarily imported from Germany but now cut off as a result of the war.

In Dr. Snelling's process synthetic crude oil is produced from hydrocarbons such as kerosene, fuel oil, lubricating oil and paraffin (themselves originally obtained from crude oil), by heating in an air-tight vessel or "bomb" until about eight hundred pounds pressure is reached, the substance occupying only about three-elevenths the volume of the bomb. The action appears to consist of a rearrangement of the atoms, and upon cooling, crude oil is obtained. This synthetic crude oil, when subjected to fractional distillation, will give off approximately fifteen per cent. gasoline. Thus the process is cyclic and through repetition can be made to yield a large proportion of gasoline.

Dr. Rittman's process, it appears, depends upon "cracking," but the petroleum is first vaporized and then subjected to the necessary pressures and temperatures for the production of gasoline, or further, benzol and toluol. Fifty to seventy-five per cent. of gasoline is said to be attainable, besides the other products.

The Edison process has not been made public.

Both Dr. Snelling's and Dr. Rittman's processes are still in the laboratory stage and it would be useless to make any predictions as to their probable effect on the

fuel and byproduct situation in this country. However, lest some be misled into the belief that the relatively large percentage of gasoline thus obtainable will greatly affect the price of that fuel, it may be pointed out that in the Burton process, controlled and employed by the Standard Oil Co., about seventy per cent. of the crude may be converted into gasoline. It is understood, however, that ordinarily not over forty to forty-five per cent. is extracted, not because of any mechanical or chemical difficulties, but solely for commercial reasons. That is, if the market demands are such as to make it more profitable to sell forty per cent. of the heat units of the crude in the form of gasoline, thirty per cent. as kerosene, twenty per cent. as fuel oil, etc., the process will be adapted to meet these conditions. If the market demands for these products are in some other ratio, the condition will be met. In other words, the Burton process is used as a "balance wheel" to suit the market and effect the most profitable production.

Now, if the new processes are developed commercially will they not to a large extent serve a similar purpose? As an economic problem it is not reasonable to suppose that the production of gasoline will be increased to such an extent as to greatly lower its price to the consumer if the demand for the heavier oils for use in the oil engine is such as to make an increased production profitable; similarly with the other distillates.

Perhaps the most important feature of Dr. Rittman's discovery, as concerns the public, lies in the fact that it is government property and as such will be free to all. Thus the independent refiners may take advantage of it and will be able to compete with the Standard. While they will also be governed largely by market demands, they may serve as a check against any artificial boosting of prices or demands; provided, of course, their supply is unhampered. Again, the production of the toluol and the other residuals, while possibly unable to compete with the imported coal-tar products after normal conditions have been resumed, will nevertheless serve as an important asset in time of necessity.

Listing Motor Data

Inadequate records of local motor installations are a common source of delay in power plants in which the operating engineer has jurisdiction over electrical as well as steam equipment. Trusting to memory as to the size and speed of individual motors may be all right when only a few are in service, but in a large plant it pays to keep an uptodate card or loose-leaf record showing in detail exactly what each motor is doing. The necessary data include the horsepower rating of each motor, its pulley diameter and face, the speed at normal rating, and the pulley and speed particulars of the main shaft of machinery or grouped tools driven, pinion and gear sizes, and the number, make and capacity of the machines run by each motor. In a representative mill installation where this information is maintained by the plant engineer each motor is provided with an index card bearing the above particulars; and in addition, space is left for recording test data, so that at any time the plant manager can be informed accurately of the load on any motor, just how many machines it is driving, and how many it should drive if loaded to its full rating. With modern induction motors this plant runs its machine drives in many cases on the basis of loading individual motors from fifteen to twenty-five per cent. beyond their nameplate rating. In case of any desired change in tool arrangement, alteration of stock or other modification of the installation, the engineer's record shows at a glance just what the condition of each drive was at the last test and indicates the course to be followed with reference to the addition of machines to any group or the substitution of a motor of different size to meet the proposed load conditions. Every lineshaft in the mill is identified by a letter corresponding to the card record of the motors, and the amount of time saved in making estimates of local power requirements is surprising, compared with the ordinary method of making a new power survey every time any question of importance arises in connection with the capacity of the motors.

Specifications

Judging from the evidence, the average writer of specifications has little knowledge of piping work, but a great desire to catch the unwily bidder. Many specifications are voluminous, and many and devious are the methods used to avoid telling the bidder all that he should know in order that his bid may be intelligent and his chance of loss minimized. At the other extreme are the specifications that are manifestly lacking in detail.

Specifications of either kind are neither creditable to the architect or engineer who wrote them, nor valuable to the owner, nor are they in the interest of clean competition. Rather do they work against the honest bidder, who justly refuses to spend his time doing the architect's work, knowing from experience that others competing with him, with less respect for their trade, are only too willing to propose a system that will just pass. The honest bidder and the owner are the injured parties, and the less conscientious bidder has a field for his activities. It is true that piping work must conform to certain regulations, but the opportunity to skimp the job is ever present, and in heating work the chances are still greater and the use of inferior material more frequent.

After the contract is secured, there is invariably constant wrangling over the interpretation, both parties putting forth good reasons for their contradictory renderings, the owner trying to get the best service at the least expense and the contractor striving his utmost to make the contract call for the least material and labor. There is also room for argument regarding the acceptance of material supposedly "equal" to that called for, the final judgment being usually left to the representative of the architect, whose experience in such matters is by no means commensurate with the dignity of the position he is to fill.

Why should specifications not be written with precision, so as to be deserving of respect, inspiring the desire for clean competition, with scant opportunity for work that will barely pass?

The advocates of the Water Power Trust claim that it is better that the water powers should be developed, even at the expense of turning them over to private capital for this purpose, than that they should lie dormant and the fast diminishing coal supply be burned up to produce the power which they might generate. It is probably better that anthracite coal should be mined and supplied to the public even at eight dollars a ton than that it should lie in the ground, but it would be a whole lot better to have it mined by the people themselves and made available at half the cost. Don't let the white coal get where the black is.

Correspondence

Two Ways of Going to Work

It takes me from twenty to twenty-five minutes to get to my work. One morning, across from me in the car was a fellow who was very much engrossed in reading some article in POWER. Next to him was another man sound asleep, with his feet stuck out in the aisle. The former seemed to be enlightened on some subject which had puzzled him. The other, dead to the world, was keeping passengers busy stepping over his feet.

At the shop I again noticed the same two men. The "dead one" was at the drinking tank, complaining to a fellow workman about the small pay he was getting; the other was busily engaged with his work. I learned that they were getting the same pay, although the dead one had worked twice as long at the place. I went my way, satisfied that I had a mirror worth holding up to my fellow readers.

MILTON W. ELMENDORF.

Wilkinsburg, Penn.

[The cartoon in this issue was drawn from a sketch accompanying the above letter.—EDITOR.]

Auxiliary Exhaust Valves on Uniflow Engines

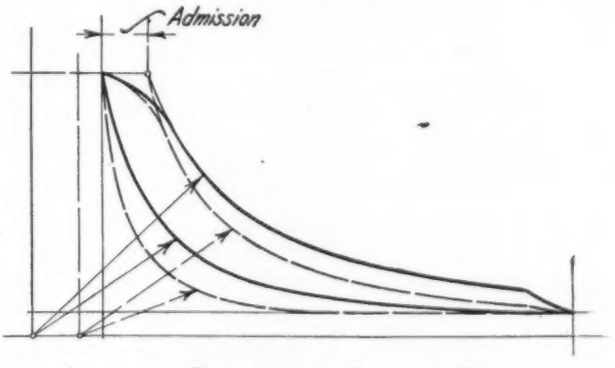
I have read with great interest the letter in the Mar. 30 issue of POWER, criticizing Professor Stumpf's article on the uniflow engine. In view of the distance of Professor Stumpf and the delay in the mails due to the war, I take the liberty of replying to this article. I was associated with Professor Stumpf during the introduction of the uniflow engine in Germany and am familiar with his work.

The question at issue seems to be whether or not uniflow engines should be fitted with auxiliary exhaust valves. There can be no question that condensing engines are better without these valves. They not only add to the mechanism and complication of the machine, but they decrease the thermal efficiency even if locked closed and absolutely tight, as they must have some clearance; and as the steam remaining in this clearance is not raised in pressure by compression, it causes a much greater loss than the same amount of clearance at the end of the stroke would.

It is true that when uniflow engines were first brought out several cylinders were wrecked, but these were cracked by initial strains due to improper design and not by high compression. There have been two accidents in this country that were probably due to excessive compression caused by loss of vacuum, but these engines had Corliss valves which could not lift sufficiently to relieve the pressure, and they broke at the cylinder heads and not through the exhaust ports.

The fact that there is in successful operation in Europe more than 600,000 hp. of condensing uniflow engines without auxiliary exhaust valves and that engine builders continue to leave them off, is proof that they are not required for safety. Since the first engines were built there has not been a single accident of the kind mentioned above with an engine built from Professor Stumpf's design.

The question of noncondensing engines presents a different problem. The uniflow engine requires large clearance and consequent loss (Fig. 8 of the article in question is incorrect and misleading, as may be seen from the accompanying cut, in which both cards have the same admission; the loss is by no means the shaded area *B*, as the description of Fig. 8 states), but this loss decreases with high steam pressures and low back pressures. Auxiliary exhaust valves also cause additional losses due to partially defeating the uniflow advantage and the additional clearance as mentioned above. These losses increase with high steam pressures and low back pressures. We therefore have two engines—one in which



AUXILIARY EXHAUST ON UNIFLOW ENGINES

the efficiency increases as the steam pressure increases and the back pressure decreases, and the other in which the efficiency decreases as the steam pressure increases and the back pressure decreases. The engine with auxiliary exhaust valves must be more efficient at low steam pressures and high back pressures, and the engine without auxiliary valves must be more efficient at high steam pressures and low back pressures.

Where these curves of efficiency cross cannot be accurately determined until there are more data of authentic trials of these types available than at present, but from the data at hand it is probably somewhere between steam pressures of 120 and 150 lb. at atmospheric exhaust.

It must not be understood that it is necessary only to build an engine on the uniflow principle to make it economical. There is just as much difference between uniflow engines as between those of any other type, and the engine must be properly designed to get good results.

I am not surprised that "One American builder, after having built and thoroughly tested a noncondensing uniflow engine having no auxiliary exhaust valves, now refuses to bid on the uniflow engine for noncondensing service," if he cannot build an engine which will do better than 24¼ lb. of steam per hp.-hr. If this engine had been properly designed for the work, it would have done at least 25 per cent. better.

One test does not prove anything, especially if the results are negative, and it is of no value whatever unless all conditions are noted.

There have been many trials by disinterested experts, and records as low as 14 lb. of steam per i.hp.-hr. (non-condensing) have been made with uniflow engines without auxiliary valves, and these records have never been approached with engines fitted with auxiliary exhaust valves.

W. TURNWALD,

Syracuse, N. Y.

Making a Spray Cooling Pond

High efficiency, low first cost, durability and attractiveness are the chief merits claimed for the cooling pond described herewith and illustrated in Figs. 1 and 2. The jets of spraying water have all the charm of a collection of fountains—a sight incomparable with the old-style towers or the newer masonry towers. The device described belongs to the Rea Patterson Milling Co., of Coffeyville, Kan.

Besides the pleasing appearance, the next important feature of this device is its durability. Being all iron and concrete, there is practically no wear and nothing to require attention or get out of order, and there is no danger from wind storms. Fifteen pounds' pressure is all that is required to operate the spray. The loss by evaporation is about the same as in other spray cooling devices.

This cooler handles 1500 gal. per min., reducing the water to normal temperature. This is regulated by the pressure, and thereby the height to which the spray rises; the humidity of the atmosphere is also a governing factor. The cost of the plant was as follows (estimated): Ground, $400; excavating (800 yd.), $250; concrete and labor, $1250; iron pipes and nozzles, $550; total, $2450.

The cost of a cooling tower with fan to perform the same amount of work was estimated at $5000. The brass

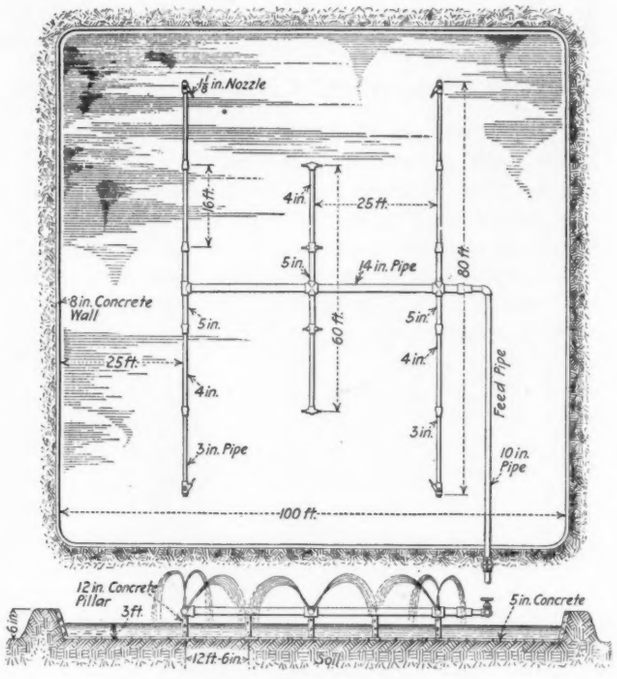


FIG. 2. PLAN AND ELEVATION OF COOLING POND

nozzles are of special make and cost $500 for the twenty used. The bottom of the pond is lined with five inches of concrete and the depth of water is about three feet. The concrete columns supporting the pipes are 12 in. square in cross-section, and they are spaced 12 ft. 6

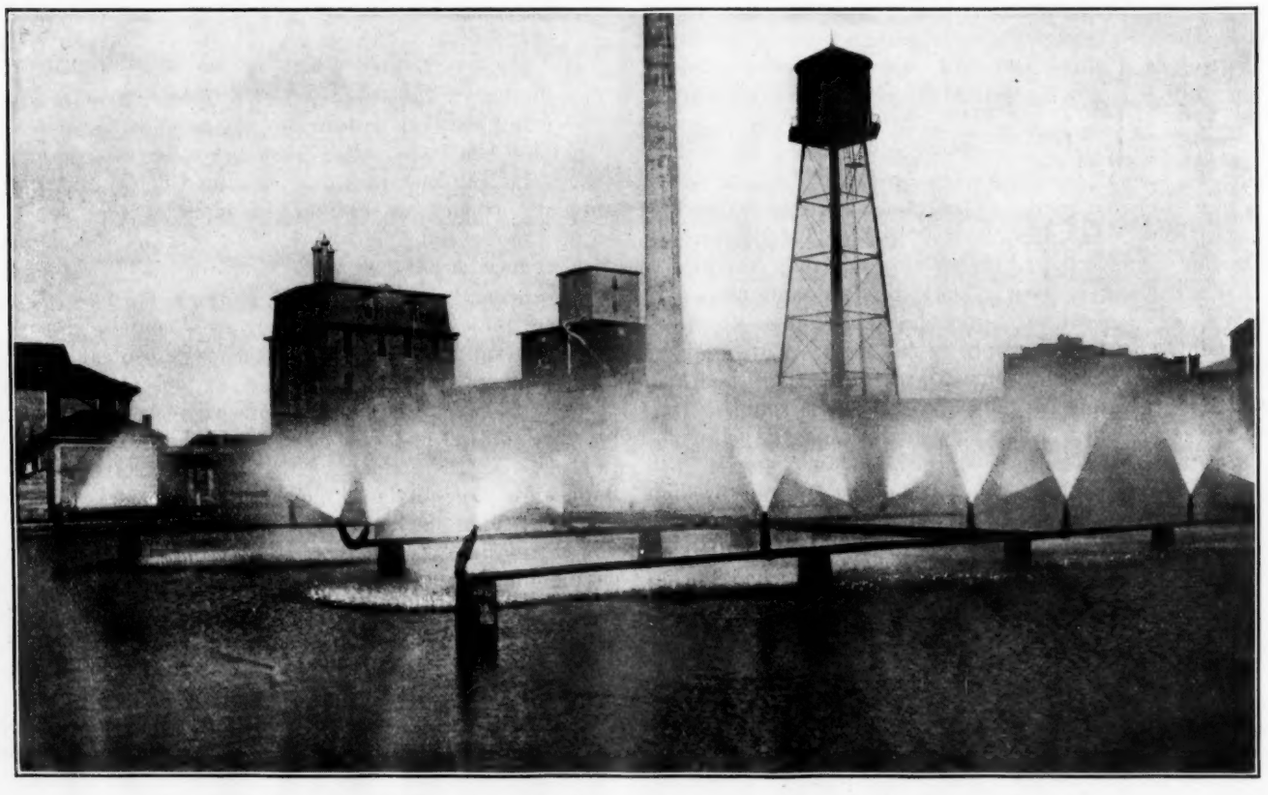


FIG. 1. COOLING POND DESIGNED AND INSTALLED BY THE PLANT'S OPERATING ENGINEER

in. apart on straight runs. The cooling pond has been in service about a year.

J. I. BLAIR.

Coffeyville, Kan.

Plate Valve for High-Speed Air Compressors

I have read, with much interest, Mr. MacFadden's article on "Plate Valves for High-Speed Air Compressors," appearing in the Mar. 16 issue, and I wish especially to refer to the statement that it requires less power to operate these valves than it does other types of valves.

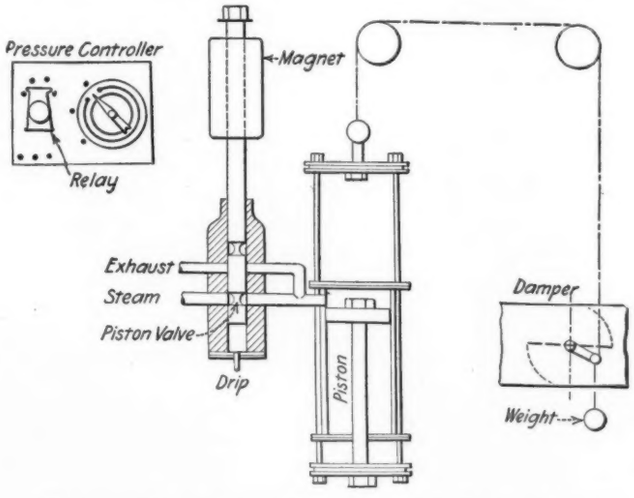
I have heard several discussions on the actual pressure required to open inlet and discharge plate valves and there seems to be a wide difference of opinion as to the actual pressure required. Many of us are interested in this subject and would be interested to know if there are any actual data by which we can determine the pressure required to open these valves. I presume that this, to a certain extent, depends upon the design of the valve, but authentic published data will be highly interesting.

J. I. BLOUNT.

Birmingham, Ala.

Electrically Controlled Damper Regulator

The function of a damper regulator is to check the draft when the boiler pressure reaches a predetermined limit. Having determined the amount of air required to burn a certain kind of coal and the quantity that it is desired to burn per square foot of grate area per hour,



DAMPER REGULATOR ELECTRICALLY CONTROLLED

it is desirable that the flow of air through the fire bed be maintained as nearly constant as possible. The damper should remain shut only long enough to check the rise in pressure and reopen when the pressure has decreased one pound below the predetermined limit. If it requires 0.68 in. of draft to burn No. 1 buckwheat coal at 20 lb. per sq.ft. of grate area per hour, and the damper is adjusted to control the air supply to that amount, then the regulator should open and close between the limits of 1-lb. rise and fall in steam pressure, and the fire will be allowed to cool but little before it is burning again at the full intensity. It will be found that under that close regulation with natural draft a much more uniform and higher average CO_2 can be maintained and the efficiency of the boilers increased, with the resulting saving in coal. The illustration shows an electrically controlled damper regulator that I designed to meet conditions where the closest possible regulation is expected. The results with natural draft are nearly equal to those obtained by a balanced draft system without the use of blowers, which increased the cost of power required to operate such systems.

HENRY W. GEARE.

New York City.

Formulas for Bumped Heads

In the editorial in POWER of Feb. 9 on "Formulas for Bumped Heads" you failed to mention several with which engineers should be made familiar. Here are some:

Mind everybody's business but your own.

Always butt in where you are not wanted.

If your boss happens to be a large man and tells you that you are not on your job, call him a liar.

Pick out a good husky fireman and kick him in the slats.

Fail to duck your nut when you pass under a low pipe line.

Come home at 2 a.m., stewed to the gills, and tell your wife that you had trouble at the plant and had to work overtime.

These few will no doubt direct a course of investigation which will result in digging up many more "formulas for bumped heads."

E. L. AINE.

Reading, Penn.

Laying Up Boilers

Some years ago I had the opportunity of experimenting in preparing boilers for a long period of idleness. The steam generators consisted of three horizontal-tubular boilers, 100-hp. each, and were in good condition. The feed water being badly incrusting, a boiler compound was used to prevent pitting and corrosion.

Before laying up the boilers they were cleaned inside and out and a coat of red lead spread on all accessible external parts. Boiler No. 1 received the following treatment: The inside was dried and a box of quicklime was put in to absorb any moisture remaining. Before closing, a pan of charcoal was burned to consume the oxygen of the air. The handhole plates were then replaced and the boiler made practically air-tight. Boiler No. 2 was filled with water and 150 lb. of soda dissolved in it, which is equal to 50 lb. to each 100 cu.ft. of water. All openings were then tightly closed. Boiler No. 3 was completely filled with feed water, and all the air was allowed to escape through a valve at the top. In each boiler was hung a polished wrought-iron bar.

Nine months later I was called back to prepare the plant for operation. On opening boiler No. 1, the iron bar was found to be slightly rusted, but the oxide was easily rubbed off with the finger. The bar hung in No. 2 was as bright as the day it was put in. Boiler No. 3 was found to have lost about half its water in some way, leaving the bar above the water line. This bar was badly

rusted, the corrosion having eaten into the metal $\frac{1}{32}$ in. My opinion is that the dry method is the best and cheapest, there being no danger of freezing in extreme cold, and no water to leak out.

K. HUDSON.

Spokane, Wash.

Reseating a Ball Engine Valve

The following shows what may be done in an out-of-the-way place when there is a will to do it. The valve and valve seat of a Ball engine, Fig. 1, being worn, the valve was sent to the shop and overhauled, but the engine could not be spared long enough to send the cylinder away.

The tool shown in Fig. 2 was made to true the upper seat after the lower one had been leveled and scraped.

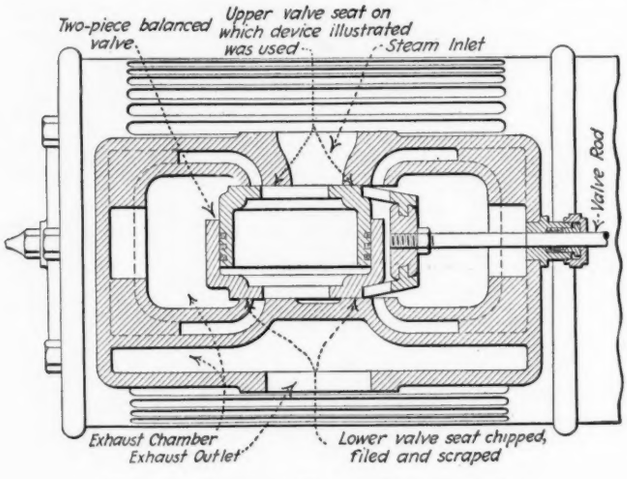


FIG. 1. TYPE OF VALVE OPERATED ON

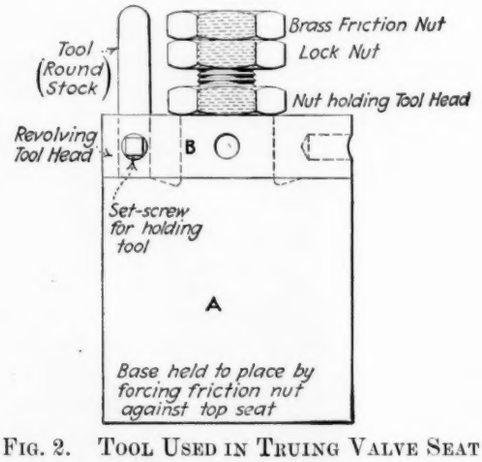


FIG. 2. TOOL USED IN TRUING VALVE SEAT

It consists of a cast-iron block *A* for a base and a revolving tool head *B*. The cutting tool was set away from the center far enough to swing across the width of the face of the seat. Four holes were bored to receive the small bar used to rotate the tool head. The tool was set upon the lower seat and the adjusting nuts set up against the upper seat lightly; the tool was then adjusted to the desired cut, and the head rotated with the bar in one hand, while the base was held steady with the other. The adjusting nut required frequent changing at first, but as the work progressed only slight adjustments were necessary. A surface approximately 8x10 in. was gone over in about five hours, taking a cut from almost nothing to $\frac{3}{64}$ in. The tool cost $5, making a satisfactory job at a low cost.

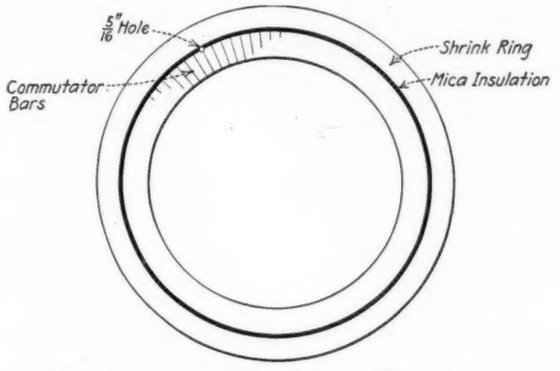
R. A. JANNET.

St. Joseph, Mo.

Quick Repair to Commutator

We have three 1500-kw., 600-volt, direct-current generators for operating a street-railway system. These run at 750 r.p.m., and the commutator bars are held in place by three shrink rings which are separated from the bars by mica insulation.

A short-circuit developed between two of the bars, and



ILLUSTRATING HOW REPAIR WAS MADE

investigation showed that it was directly under one of the shrink rings. To save the time and expense required to take off the shrink ring, a $\frac{5}{16}$-in. hole was bored between the two bars showing the short-circuit; it being necessary to drill nearly the whole depth of the shrink ring. After the short was cleared the hole was filled with a composition of mica and shellac, and the machine was put back in service after twelve hours' shutdown and has since been operating and carrying full load without difficulty.

J. B. CRANE.

Duluth, Minn.

Air Hose and Bucket as Ammonia Helmet

To be able to remain calm when there is a serious ammonia leak about the plant is a valuable asset to a refrigerating engineer.

The following is an excellent example of the engineer doing the right thing at the right time. He was operating an absorption plant when a serious break in the ammonia end of the aqua pump occurred. Before he could shut the valves the ammonia fumes had become so strong that he was compelled to leave the room. The engineer realized that the charge of ammonia would be lost unless the valves were shut immediately. Reaching in through a window he pulled the air hose loose from the air hoist. He then put the end of the hose into a three-gallon water bucket, and with the hose at the back pulled the bucket down over his head, and with his improvised helmet was able to get at the valves to save the ammonia. The air, which was at a fairly high pressure, blew the ammonia fumes from his face.

G. A. ROBERTSON.

Atlanta, Ga.

Selecting a Pump

Mr. Lent's criticism in the Mar. 9 issue, of the writer's article on pumps in the Feb. 9 number, seems to be devoted largely to deploring the latter's lack of knowledge upon the subject rather than to imparting useful information to replace that which he discredits.

The suggestion that the priming of a centrifugal pump should have been mentioned is a good one. The length of the article, however, did not allow of a discussion of many of the important details relating to the various types mentioned, and this was omitted, with others of a similar nature. Possibly a second reading will bring out the fact that the matter of distance was not the only factor noted regarding the selection of a pump for a given set of conditions.

A deep-well pump having an efficiency over 80 per cent. and no slip, is interesting as showing what can be done through good design and careful adjustment, but is hardly to be taken as current practice. The Deming Co., large manufacturers of this type of pump, give average efficiencies even lower than the ones criticized, while those for triplex pumps are practically the same as given by the writer.

Methods employed for increasing the flow of artesian wells are discussed in detail by Professor Turneaure, in "Water Supply," Part I, American School of Correspondence, and might be of interest to Mr. Lent. The use of the air lift for increasing the flow of artesian wells has been recommended to the writer by the consulting engineer of a large concern making a specialty of sinking wells and installing pumps of various kinds.

Gebhardt's "Steam Power Plant Engineering" gives the efficiency of direct-acting steam pumps as varying from 50 to 90 per cent., according to the conditions under which they are operated, with an average of about 65 per cent. for actual practice. The writer's estimate of 60 to 80 per cent. does not appear to be outside the usual limits. The Lawrence Machine Co. recommends efficiencies of 50 to 60 per cent. when estimating the power for driving centrifugal pumps of the type used for circulating hot water in heating systems, while tests of high-class machines, as given in standard works on pumps and published in the catalogs of the Worthington and De Laval companies, show efficiencies running from 70 to 80 per cent. The range of 60 to 80 per cent., as given in the article, does not seem unreasonable when compared with average results.

Regarding the statement relating to the action of volute and turbine pumps, Gebhardt's "Steam Power Plant Engineering," pages 630-631, may throw some light on the matter.

In brief, the writer has no desire to discredit the views of Mr. Lent or enter into any controversy, but he wishes to emphasize that the statements made in the original article seem to be well supported by authorities of high standing and to be based on average current practice.

CHARLES L. HUBBARD.

Boston, Mass.

Charles L. Hubbard's article, "Selecting a Pump for General Service," in the Feb. 9 issue is of interest, and may be modified and enlarged upon without limit. The following may be of additional interest.

It may be worth while to note that the usual steam consumption for this type of pump is more nearly 200 to 250 lb. per developed horsepower per hour than 80 to 160 lb. The latter would be difficult to obtain under ideal conditions of tight steam valves and pistons working on smooth, polished, well lubricated surfaces, the best hydraulic piston packing, fitting snugly to the water-cylinder barrel, and tight suction and discharge valves. Even this extravagant use of steam is not a serious disadvantage when the pump is installed under proper service conditions, as the exhaust steam can often be used advantageously.

Under normal operating conditions direct-acting steam pumps should not have a slippage of more than 5 per cent., and any pump having 15 to 20 per cent. should receive prompt attention from the operating engineer.

A normal speed of 100 ft. per min. is conservative. Boiler-feed pumps frequently operate at half this rate, while general-service pumps operate satisfactorily at 50 per cent. excess speed. The piston speed of a pump has little or no relation to its proper operation unless the valve area is restricted. The important consideration is the number of piston reversals, hence the number of times the flow of water is interrupted. The higher the speed the lower the steam consumption per indicated horsepower per hour, due to the reduced cylinder condensation.

A single, or simplex, pump is one having a single steam and water cylinder arranged along the same center line. A duplex pump is two single pumps placed side by side, the steam valves receiving their motions from the piston rods of the opposite sides. Owing to its simplicity, positive operation and even rate of discharge, the duplex type is often preferred, although the single pump has a slightly lower steam consumption.

Power Pumps

The power pump has more universal application than the steam pump, because of the extensive use of electricity and the gas and oil engine, to which it is either belted or directly connected. The belt drive is preferable, as it is quieter, more flexible, and provides a safety, which may prevent serious damage to the pump. It is frequently objected to where the pump is to be automatically started and stopped. In such cases, the belt should be selected with care and the drive carefully laid out.

The belt should not be allowed to run slack or slip, as this eventually results in its destruction, and interrupted service. A proper-sized belt, cut from the best hide, thoroughly stretched, carefully made and rightly installed, with an idler for maintaining a constant tension, is a most satisfactory drive and should operate for years. Where an idler pulley is not desired or where there is much moisture, a rubber belt will give more satisfactory service than leather. If the space is limited, a close-belted idler drive is to be preferred to a gear drive, and especially is this so in apartment houses and office buildings, where the noise of the gears may be transmitted through the piping system.

The power pump is much used for elevator, domestic and irrigation service, as it may be conveniently located and long lines of steam pipes are eliminated. The discharge is positive, hence a relief valve should always be placed in the discharge line, close to the pump, to prevent excessive pressure and damage to the pump.

In the larger sizes and where the plunger loads are reasonably large, the efficiency is from 80 to 90 per cent.

A slippage of 15 to 20 per cent., as stated by Mr. Hubbard, is excessive; it should not be more than 3 to 5 per cent. Most power pumps, especially the vertical triplex, are outside-packed and the slippage past the plungers is evident.

Power pumps are either horizontal or vertical; the larger sizes are usually horizontal. Both types are built single, duplex, triplex or quintuplex. The vertical triplex is the most popular high-grade power pump, because of its moderate cost, smooth discharge and generally satisfactory service.

Deep-Well Pumps

This class of pump performs the most severe kind of work, and there are indeed few deep-well pumps which render reliable service year in and year out. There is great difficulty in maintaining the well rods, which frequently reach five or six hundred feet to the water level below the ground, and in some cases of oil wells, three or four thousand feet below the surface. Because of their great length and the large inertia stresses due to the rising and falling column of water, the rods are frequently broken, and until the wreckage can be removed and the rods renewed the service is interrupted.

The vertical artesian steam engine is so cushioned that rod troubles are slight on wells up to 200 ft. deep. The power-well head has troubles all its own, especially on deep wells. The difficulties have, however, been largely eliminated by the triple-plunger barrel and well head, known as the "Glendora" deep-well pump, manufactured by the Deane Steam Pump Co. With this construction the column of water is always moving upward. There is no reversal of stress in the well rods, and the efficiency is 85 per cent. and more, as against 65 to 70 per cent. for the single-acting power-well head.

Mr. Hubbard states that deep-well pump efficiencies are 40 to 50 per cent. This is true only of the centrifugal type. There are installations where centrifugal deep-well pumps give better initial efficiencies, which are maintained only by frequent tuning up.

Centrifugal Pumps

Centrifugal pumps are most desirable for clear water and low heads. Efficiencies of 60 to 80 per cent. are normal, but appear absurd if the slippage is as great as 20 to 60 per cent., as given by Mr. Hubbard. The foregoing, of course, assumes that the pumps are of good design and construction, properly maintained and operating under suitable conditions. It is evident that the discharge head might be so great that there would be no discharge and the slippage would then be 100 per cent. A slippage of 20 to 40 per cent. would be reasonable for a well designed pump operating under the conditions for which it is designed.

A peculiar characteristic of a centrifugal pump is that, as the pressure on the discharge is increased above some fixed pressure for a particular pump, the required driving power is reduced, and, as the pressure is reduced the required driving power is increased. For this reason the centrifugal type is not adapted to fluctuating conditions of service.

Air Lifts

The air lift as a pump would be simple were it not necessarily complicated with compressors and air-storage tanks, which are more or less dangerous and in some states must be regularly inspected by a properly authorized inspector. The efficiencies given by Mr. Hubbard are misleading, as the net overall efficiency is generally between 20 and 30 per cent., with isolated cases of better efficiency.

Hydraulic Ram

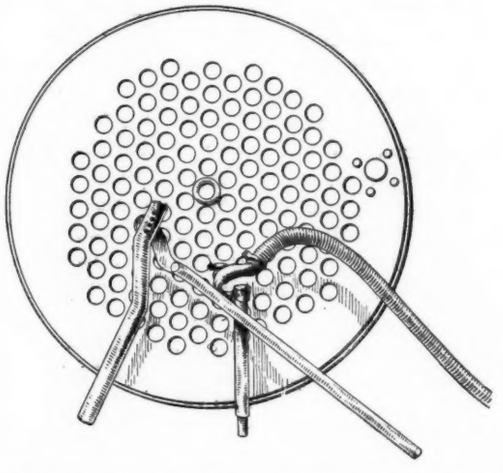
A hydraulic ram would hardly be considered as a pump for general service, and it may be located only where the supply of water is itself elevated.

Robert E. Newcomb,
Supt. Deane Steam Pump Co.

Holyoke, Mass.

An Ingenious Repair Job

A small vertical boiler on a locomotive crane at the works of the Champion Fibre Co. at Canton, N. C., required a new set of flues and an upper flue sheet. Time being the essence of the contract, a novel means was employed by the boiler maker. To avoid the necessity of removing the firebox in order to get inside to hold the "dolly" on the head of the rivets while driving, a piece



Dolly-Bar and Hammer Used on Repair Job

of 3-in. shafting, the right length to reach from the center flue hole to the rivet heads, was prepared, hinged and pinned to a lever put through the center flue opening (which was bushed to prevent injury to the edge).

The new head was fitted in place in the usual way and the riveting process was carried on in the following manner: The heated rivets were passed inside of the boiler to a pair of long, specially made tongs operated, through one of the tube holes in the lower head, by a man stationed in the firebox. He in turn placed the rivet in the proper hole. Then the end of the dolly-bar was brought to bear on the rivet head as described and the pneumatic riveter "turned loose" on the outer end. The cost of the job and the time consumed were, of course, materially less than they would have been if done in the ordinary way.

H. Kilday.

Canton, N. C.

[We presume there were "good and sufficient" reasons for not wishing to invert the heads and drive the rivets from the outside. The rather unsightly appearance of such a job is sometimes objectionable.—Editor.]

Inquiries of General Interest

Temperature for Pouring Babbitt Metal—How can the proper temperature for pouring babbitt metal be known?

F. L.

When a yellowish tinge has formed on the surface, or if a white-pine stick is heavily browned or slightly charred when inserted in the molten metal, then the proper temperature has been reached for pouring.

Disadvantage of Low Boiler Settings—What is the disadvantage of low, as compared with high settings for return-tubular boilers?

C. B. L.

Settings which are too low may be wasteful of fuel, for when a boiler is set too close to the grates the flame is cooled by coming in contact with the boiler surfaces before combustion has been completed.

Calculation of Calorific Value of Coal—How is the calorific value of coal determined from its analysis?

J. M. E.

The heat value of any coal may be calculated from its ultimate analysis, with a probable error not exceeding 2 per cent., by Dulong's formula,

$$\text{Heat value in B.t.u. per lb.} = 146\,C + 620\left(H - \frac{O}{8}\right) + 40\,S$$

in which C, H, O and S are the respective percentages of carbon, hydrogen, oxygen and sulphur present in the coal.

To Draw True Vacuum Line on Indicator Diagram—How is the true vacuum line drawn on a steam-engine indicator diagram?

M. G.

The line representing true vacuum would be below the atmospheric line a distance which represents atmospheric pressure. Therefore, at sea level the true vacuum line is to be drawn with a straightedge below the atmospheric line of the diagram, and parallel to it, at a distance which, according to the scale of the indicator spring, represents 14.7 lb. per sq.in.

Objections to Sulphur in Coal—What are the objections to the presence of sulphur in coal for steaming purposes?

C. R. S.

The calorific value of sulphur is less than $\frac{1}{10}$ that of carbon, and its presence in fuel is objectionable because the gases formed from its combustion attack the metal of the boiler, causing rapid corrosion, especially in the presence of moisture. Sulphur is also objectionable because it unites with the ash of the coal to form a fusible slag, or clinker, which chokes up grate bars, forming a solid mass having embedded in it considerable quantities of unconsumed carbon.

Absolute Temperature—What is meant by absolute temperature?

G. R.

Since substances can be cooled below the zero point of the ordinary thermometer, it does not represent the true zero of temperature at which there is an entire absence of heat; and while this has never been reached in cooling substances, experiments indicate that it is 460 deg. below the zero of the Fahrenheit scale. Hence, to change Fahrenheit degrees to absolute temperatures add 460 to, or to change from absolute to Fahrenheit degrees, subtract 460 from, the number of degrees.

Obtaining Length of Open Belt—What is the rule for finding the length required for an open belt?

R. B.

The best method is to measure the length directly by passing a tape line around the pulleys. When this cannot be done an approximate formula is

$$\text{Length} = 2\,L + 3.1416\,(R + r) + \frac{(R - r)^2}{L}$$

in which all dimensions being in feet or inches,

L = The distance between centers of the pulleys;
R = Radius of larger pulley;
r = Radius of smaller pulley.

Loss of Draft in Flues and Elbows—What is the relative loss of draft in round and square smoke flues and what allowance should be made for elbows and lengths of flues?

W. C.

The retarding effect of a square flue is about ⅛ greater than for a circular flue of the same area, and for brick flues is about ¼ greater than for steel flues. Short right-angle turns reduce the force of draft about 0.05 in. for each turn and a circular steel flue the same size as the stack causes about 0.1 in. draft loss for each 100-ft. length of flue. In average power plants it is usually practical to reduce the loss of draft by providing a smoke flue with a cross-sectional area about 20 per cent. greater than the cross-sectional area of the stack.

Duty of Steam Pump—What is meant by the duty of a steam pump?

H. N. M.

The duty of a steam pump is the number of foot-pounds of useful work realized, or the equivalent number of pounds of water lifted 1 ft. high, per 1,000,000 heat units furnished by the boiler; i.e.,

$$\text{Duty} = \frac{\text{Foot-pounds of work done} \times 1{,}000{,}000}{\text{Total number of heat units consumed}}$$

The old unit of comparison was the number of foot-pounds of work realized per 100 lb. of coal, and this was inexact, as the amount of steam depended upon the quality of the coal and the evaporative efficiency of the boilers. The modern unit of comparison is not seriously at variance with the old unit, as in good boiler practice 1 lb. of coal will yield at least 10,000 B.t.u. in generation of steam.

Loss of Heat from Steam Pipe—What would be the loss of heat from an uncovered 6-in. steam pipe 80 ft. long, containing steam at 100 lb. gage pressure?

W. B.

Bare pipe will radiate approximately 3 B.t.u. per hour per square foot of exposed surface per 1 deg. of difference in temperature between the steam contained and the external air. The temperature of steam at 100 lb. gage pressure being 338 deg. F., and assuming the temperature of air surrounding the pipe to be 80 deg. F., then the loss of heat would be

$$(338 - 80) \times 3 = 774 \text{ B.t.u.}$$

per hour per square foot of exposed pipe surface, and as the external diameter of 6-in. pipe is 6.625 in., the total pipe area exposed would be

$$\frac{6.625}{12} \times 3.1416 \times 80 = 138.75 \text{ ft.}$$

and the loss of heat would amount to

$$138.75 \times 774 = 107{,}392.5 \text{ B.t.u. per hour.}$$

Equivalent Evaporation—With an average temperature of feed water of 136 deg. F., 2900 tons (each 2240 lb.) of coal were required to evaporate 38,000,000 lb. of water into steam at an average gage pressure of 137 lb. per sq.in. What was the equivalent evaporation from and at 212 deg. F. per pound of coal?

J. A. M.

The evaporation under the actual conditions was

$$\frac{38{,}000{,}000}{2900 \times 2240} = 5.849 \text{ lb.}$$

of water per pound of coal. The steam tables show that 1 lb. of steam at 137 lb. gage, or about 137 + 15 = 152 lb. absolute, contains 1193.6 B.t.u. above 32 deg. F., and as each pound of the feed water contained 136 — 32 = 104 B.t.u., then for conversion into steam at the stated pressure each pound of feed water received

$$1193.6 - 104 = 1089.6 \text{ B.t.u.}$$

As the latent heat of evaporation of a pound of water at 212 deg. F. is 970.4 B.t.u., the factor of evaporation was

$$1089.6 \div 970.4 = 1.1228$$

hence the actual evaporation was equivalent to an evaporation of

$$5.849 \times 1.1228 = 6.567 \text{ lb. of water}$$

from and at 212 deg. F., per pound of coal.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Testing Lubricating Oils*

SYNOPSIS—An enumeration of the various tests to determine the qualities of an oil. Results obtained are only approximate.

A brief description of a desirable lubricant is that its viscosity should be the least possible which will allow it to stay in place and do the work. Summarizing the commonly desirable characteristics, they are:

1. The oil should possess cohesion.
2. It should possess the maximum possible adhesion.
3. It should be as far as possible unchangeable.
4. It should be commercially free from acid.
5. It should be pure, that is, it should be what it purports to be.

TYPES OF VISCOSIMETER

The first to be discussed is the viscosity test, which is used to measure the internal friction of the oil, or, as an engineer might put it, the shearing modulus. This test is of value because a lubricant is really used to keep a shaft or journal and its bearing apart. The journal really revolves on a sheet of lubricant, an action which has been described as revolving on the molecules of the lubricant. The ease with which the molecules slide over one another therefore determines, to a certain extent, the friction loss in a bearing.

A fine example of the effect of the viscosity of lubricating oil is furnished by an experience in a certain spinning mill. This mill was operated with power derived from an engine carrying about the maximum load of which it was capable. The lubricant used on the spindles was changed to one which was supposed to be better. It was then found that the engine did not have power enough to drive the machinery in the mill; as a matter of fact, it was unable to start the machine in motion. Examination showed that the only essential difference between the two lubricants was the possession of higher viscosity by the new oil.

The measurement of viscosity of lubricating oils is in a certain sense unsatisfactory, because the results obtained with the different instruments which are available for making this test do not agree among themselves. It is therefore customary to state the instrument which was used in determining any quoted viscosity.

One of the most commonly used viscosimeters is the Saybolt instrument. This is of the pipette type, having a tall pipette of rather small diameter immersed in a jacket which may be used for maintaining any desired temperature during the test. The test is made by filling the pipette to a certain point and noting the time of efflux, in seconds, which is taken as the measure of the viscosity of the oil tested. Or the so called specific viscosity may be determined by dividing the time required for the efflux of the oil by the time required for the efflux of the corresponding volume of water. The Saybolt instrument was developed by the Standard Oil Co. and was used as a standard for many years, and is today.

The instrument most commonly used in Germany, and now coming into rapid use in this country by both the Government and individuals, is known as the Engler viscosimeter. This differs from the Saybolt principally in using a shorter pipette of larger diameter. It is used in the same way, but the specific viscosities as determined by the two instruments do not agree.

None of the commercial viscosimeters really measure the viscosity, becaues it can be shown that the tube through which a jet is discharged must have a length of from 175 to 200 times the diameter to give a true measure of viscosity. Any of the commercial instruments can, however, be standardized by measuring the times of efflux of standard solutions of cane sugar or of glycerin. By such means the readings of these instruments can be interpreted in terms of absolute viscosity in dynes.

Numerous viscosimeters made of glass have been tried, but unfortunately no two glass instruments can be made exactly alike except at prohibitive expense. For this reason, the glass pipette once used as a standard by the Pennsylvania R.R. was abandoned. It should, however, be noted that a glass pipette, calibrated with glycerin as above described, can be used.

The viscosimeters just mentioned are all of the efflux variety, but there are numerous other forms available, and some of them are particularly well adapted for testing the viscosity of certain commercial products other than oils. For instance, the retarding effect exerted on a paddle revolved in a viscous liquid may be used as a measure of the viscosity and is so used with varnishes, glue and paste. Another form consists of a cylinder suspended from a torsion wire. The retarding effect upon this cylinder when swinging back to normal position after a displacement can be used as a measure of viscosity.

It should be particularly noted that the viscosity varies rapidly with the temperature. It is therefore necessary to state the temperature at which any determination was made.

FRICTION TEST

There is really no satisfactory test of the adhesive quality of a lubricant. It is commonly supposed to be determined by a friction test. This is made by measuring the frictional resistance offered to the rotation of a standard journal in a standard bearing when lubricated with the oil in question. The results obtained depend partly upon the viscosity of the lubricant and partly upon its adhesion. Modern research shows that viscosity tests show about as much as do friction tests, but this is not necessarily so, and must not be assumed to be universally applicable.

GUMMING TEST

A third test, and one which is of great importance, is known as the gumming test. This is particularly applicable to petroleum oils and is used to indicate the extent to which the oil has been refined. It serves indirectly to indicate the extent to which the oil may be expected to change due to oxidation when in use. Numerous opportunities have been offered to check the results obtained with this test and results obtained in practice with the same oils, and all of this experience tends to show the great value of the gumming test.

This test is made by putting a small quantity of the oil to be tested in a small glass vessel, such as a cordial glass, and then mixing with it an equal quantity of nitrosulphuric acid. A properly refined oil will show little, if any, change, but a poorly refined oil will be indicated by the separation of large quantities of material of dark color. This color is due to the oxidation of the tarry matter contained in the lubricant. Experience has shown that oils containing large percentages of tar absorb the most oxygen, that is, they are mildly drying oils.

The results obtained by the gumming test agree well with carbon-residue tests made by distilling to dryness in a glass or a fused quartz flask. The carbon-residue test has been found of great assistance in choosing a satisfactory cylinder lubricant for gas engines, as a large amount of carbon means trouble in the engine cylinder. The lowest carbon content mentioned by the author was 0.11 per cent. The oil giving this test showed no tarry matter when tested with nitrosulphuric acid. In general, a gas-engine oil should not contain more than 0.5 per cent. carbon as determined by the carbon-residue test.

FLASH, FIRE AND EVAPORATION TESTS

When an oil has been found to have satisfactory viscosity and has given satisfactory results in a gumming test, it must next be checked for safety, that is, the flash and fire test must be made. The amount of volatile matter given off at the temperature at which the lubricant is to be used is often of great importance. A case is on record in which a serious mill fire was spread by vapors given off by the lubricant used in the various bearings. The oil used in this mill gave off 25 per cent. of volatile material when raised to 145 deg. F.

It is advisable to include an evaporation test with the flash test of lubricants. The evaporation test is made by exposing about 0.2 gram of oil at a proper temperature and determining the loss by weight in a given time.

The flash test is made by heating the oil slowly in a vessel surrounded by a proper bath and determining the lowest temperature at which a flame passed over the surface will ignite the vapors which are given off.

FREE ACID TEST

It is generally conceded that lubricants should be practically free from acid, and the so-called free acid test is made to determine the extent of acid content. The mineral oils are agitated with sulphuric acid during the refining process for the purpose of removing tarry materials, and this acid must be practically all removed from the oil before it is put on the market. Oils may become contaminated with acid from another source as well; namely, the animal or vegetable oils which are occasionally mixed with them for the purpose of

*Abstract of paper read by Prof. A. H. Gill before the Detroit Engineering Society, Mar. 19, 1915.

modifying their characteristics. A content of 0.3 per cent. of acid is generally considered the maximum allowable.

SPECIFIC GRAVITY

It is often desirable to determine the character of the raw material from which a given lubricant was made. This can be done in the case of oils refined from petroleum by means of the specific-gravity test. Experience has shown that lubricants made from petroleum with an asphaltic base run from 7 to 10 deg. Baumé heavier than similar lubricants made from petroleum with a paraffin base.

In examining oils, it is well to bear in mind that the viscosity is easily increased by the use of a material known as oil pulp or oil thickener. This is really oleate of alumina, and while it brings up the viscosity, it does not give the greasiness expected when that particular viscosity was specified. At ordinary temperatures, a small quantity of this material will greatly raise the viscosity.

COLD TEST

There is another test, known as the cold test, which is of value in some cases. If an oil is to lubricate a bearing, it must be fluid enough at the temperature of use to readily flow into that bearing. Many ruined bearings and some fires have resulted from the use of an oil which became too viscous to flow under the conditions of use. For such reasons, it is customary to chill samples of oil and to determine the temperatures at which they become too thick to flow readily.

IODINE TEST

Tests other than those already described are often made on animal and vegetable oils. They are generally made for the purpose of determining whether the oil under test is what it is supposed to be. It is a simple matter to mix different animal and vegetable oils in such a way that they will give a product capable of passing any one or possibly two given tests, but it is impossible to make such a mixture successfully pass all of the tests which would be passed by the pure oil for which the mixture is to serve as a substitute.

The chemist is often at a great disadvantage in testing such mixtures, because there are no exact specific tests for some of the animal and vegetable oils. The presence of some can be determined absolutely, but unfortunately, this is not true of all.

The iodine test, by which is meant the determination of percentage of iodine absorbed by the oil under set conditions, has long been used to indicate the character of vegetable and animal oils present in a sample. At one time it was believed that the so-called iodine number was a constant for any one oil and that this test was therefore perfect. It is now known that this is not true, the iodine number varying with the condition of the material from which the oil was made.

It is a simple matter to determine the presence of petroleum oils in a mixture of oils with animal or vegetable origin. This is done by saponification, which serves to separate the petroleum oil, which does not saponify, from the others which do.

MAUMENÉ TEST

There is a comparatively new test, known as the Maumené test, which gives results comparable with those obtained with the iodine test, but is much simpler and therefore more readily performed by the average individual. For this test, 50 grams of oil and 10 c.c. of sulphuric acid are placed in a beaker and slowly stirred with a thermometer. The maximum temperature rise which occurs is noted and used as an indication of the character of the oil.

TESTS ONLY APPROXIMATE

It should be appreciated by the practical man that the tests of lubricating oils give only approximate results. Thus any one viscosimeter as ordinarily made will give consistent results on the same material at the same temperature, but different instruments of the same type and apparently exactly alike will give results on the same material which vary several per cent. Similarly, large errors are often obtained when using friction machines. With tests otherwise properly conducted, it appears that the absorption of oil by the metal of the journal and bearing may be sufficient to cause appreciable errors. Tests have shown that it may take several hours to eliminate the effects of the last oil tested so as to get correct results with a given sample.

No rigid directions can be given for the choice of oils for given purposes. It is best to try various lubricants which can be purchased for any given lubricating problem until one is found which gives satisfactory results. This should then be completely tested and the results of the test should be used in writing specifications on the basis of which bids are to be asked. When the problem is handled in this way, the different prices asked for lubricants which will meet the same specifications will often be found most remarkable.

Wrought Iron and Steel Tubes*

By J. G. Stewart

When the British Engineering Standards Committee considered the question of screw threads for pipes they compared the merits of two well known forms of thread, viz., the Whitworth or British standard bolt thread, the Sellers, or U. S. A. standard, and another, not so well known—the Briggs American standard pipe thread. The committee decided by a majority (of which the writer was not a party) to accept the Whitworth thread, principally because the tools to make it were already in the hands of every engineer and plumber in this country, but also because taps and dies made to this form have little tendency to change by wear, which is not the case with the American standard forms of bolt and pipe joints.

However, any pipe joint, in order to be petroleum tight under high pressure (many oil lines work at 1000 lb. per sq.in.) must be of very special and accurate construction, and for this class of work the Briggs thread has alone proved satisfactory. It will be noticed that the crest of the thread is very sharp, much more so than the contour of the root. One result of this is that a difficulty occurs in maintaining the screwing tools to their correct shape. This is minimized by forming the tools to the correct profile by a single cutting tool which leaves the sharp crests on the master tap. As there is a considerable amount of cutting surface to be worn away on the master tap, the sharp edges stand up to their work for some time without losing appreciably the sharpness of the thread.

The difference in the power required to draw up a coupler with the Briggs thread, as compared with one with the Whitworth, is marked, particularly as such threads are made on a cone with a taper of $\frac{1}{16}$ in. per inch. With the Whitworth thread little movement can be given to the coupler with a heavy pipe wrench, after it has been drawn up by hand, as compared with that which can be obtained in a Briggs thread joint. There is little doubt that Briggs himself, in putting it forward in his paper which was read in America in 1886, fell into confusion. His description of his proposed thread, which was subsequently adopted as the American standard pipe thread, is as follows: "The thread employed has an angle of 60 deg.; it is rounded off top and bottom, so that the height or depth of the thread, instead of being exactly equal to the pitch, is only four-fifths of the pitch." But, having an angle of 60 deg., the depth could not be equal to the pitch. There can be no doubt that what he meant to say instead was "the depth appropriate to the pitch." This depth measures 0.866 and as the depth was to be 0.8 the amount to be taken off the sharp edge or crest was 0.066, as against 0.17 on the Whitworth standard.

The question arises, Can a joint be made in this manner—i.e., with the Briggs thread—be undone, and remade if occasion arises? The answer is that it depends upon the treatment given when the joint is first made. If the couplings are driven very hard upon the screwed ends of the pipes it may be found impossible to disengage without injury to the thread and again remake the joint. But if the joints are screwed up with proper care and with a liberal use of thick viscous oil, these joints with this form of thread can be unmade and remade five times at the least computation.

Many engineers are under the impression that a coarse thread is stronger than a fine one, but that the converse is the case may be readily demonstrated. Take a pipe or bolt, and screw it at one end with a fine thread and with a coarse thread at the other, with nuts to correspond; place a spiral spring between them and draw up until one of the threads strips. This will invariably be found to be the coarse thread.

An important item in drawing up a specification for steel pipes is the method of bending them to the required pattern. There are two ways in which a steel pipe may be bent. The straight length of pipe may be set on a table between supporting dogs and bent by drawing the free end of the pipe against the dogs. By this method the pipe is constantly under the observation of a skilled operator, who is careful to arrest any local drawing of the metal on the outside radius, by causing the pipe to thicken on the inside radius rather than to reduce on the outside. The other way is to bend the pipe between a pair of dies, each forming a half-mold of the bend to be made. Curiously enough, some engineers seem to be under the impression that the correct way to

*Abstracted from a paper read before the Institution of Engineers and Shipbuilders in Scotland, Feb. 16, 1915.

form a bend is by dies, whereas the two methods will not stand comparison.

When a piece of tube is bent into a curve, first, one side of the tube must stretch or become extended in length; secondly, the opposite side must, in a lesser degree, become shortened; and, thirdly, the cross-section of the tube must become an ellipse. Condition No. 2 is no disadvantage, and condition No. 3 can in most cases hardly matter, as the cross-sectional area is only slightly diminished. The consequences of No. 1 may seriously injure the bend, the result being a reduction of the thickness of the wall, even to the extent of rupture; this does actually take place frequently when the radius of the bend has a small ratio to that of the cross-section of the tube.

It follows that in making a bend it is desirable to control and relieve the stretching at the expense of the other two conditions. The only way of exercising this control is for an expert workman to watch the action and cool the part where he can detect thinning. Along the outside of the bend it will be more prevalent at one point than at others, and wherever it is apparent it will accentuate itself as the metal gets more attenuated and weaker. An experienced bender will stop the bending and cool the yielding part by a water jet before resuming. He may require to cool many parts many times before he completes the operation of forming his bend. This manipulation is quite impossible if the forming is done between a pair of dies.

No doubt, bending pipes in dies is a more expeditious process, suited to unskilled labor, and therefore cheaper, but the quality of the work is altogether inferior. Bending of pipes in dies should never be employed or sanctioned for anything but the sizes of pipes of, say 2-in. bore and under. To confirm this opinion one has only to drill holes in the back of two pipes bent by these two processes, when the difference in thickness of the metal will at once establish the superiority of the first mentioned method.

I have purposely avoided reference to the controversial subject of the relative merits of steel and cast iron for pipes. Some years ago, when steel pipes were introduced for the gas and water supply of our Colonial possessions and other markets far removed from the manufacturing centers, these light lap-welded tubes proved of inestimable value in developing new towns and colonies, which, had it not been for their low cost and the low freight on them, would in many cases have been without water supply to the present day. With very few exceptions these pipes have given every satisfaction, recent reports from all sides showing that they are practically as free from corrosion as when laid. This being so, there is a natural disinclination to pay the extra price and freight charges of the thicker hot-rolled weldless pipe.

As regards its application to water and gas pipes, the total value of steel pipes for that purpose manufactured last year in this country was about £7,000,000, or three times as much as it was 15 years ago. The steel pipe maker, therefore, has certainly nothing to complain about. I believe that during the same period, the production of cast-iron pipes has remained about stationary, but I have no definite statistics on this point.

A few representative cases may be cited as illustrating that the rapid transition from cast iron to steel indicated by the above figures is well warranted. For the water supply of Perth, Western Australia, a cast-iron pipe 12 in. diameter was laid about twenty-five years ago, and this was supplemented 17 years ago by a steel pipe 21 in. diameter. The former has been twice scraped to remove the internal nodular incrustation due to rust, some of these nodules being found to be from 2 to 3 in. thick. On the other hand, the steel pipe, on recent inspection, was found to be practically free from corrosion. This case is remarkable from the fact that the water is from the same source and practically identical with that pumped through the celebrated 350-mile line of 30-in. steel pipe for the water supply of Coolgardie, the internal corrosion of which in places (principally due to portions of this pipe line being allowed to run only half full, that is, between wind and water) has led to a good deal of extravagant comparison of the relative corrosion-resisting qualities of steel and cast iron coupled with the assertion that the laying of this main in steel was a false economy. The real facts of the case are that the local authorities knew full well from the above-cited experience in the Perth water supply that any trouble experienced with this main in steel would certainly have been very much worse in cast iron.

Sixteen years ago the town of Bradford laid about 15 miles of 36-in. steel pipes. At that time there was a difficulty in supplying bent pipes of this size, and the bends in the line were therefore furnished in cast iron. A recent landslide at one of these bends dislodged the leaded socket between the straight steel pipe and the cast-iron bend, when it was found that the surface of the cast-iron pipe was heavily incrusted, owing to corrosion, thus seriously reducing the capacity of the pipe, but the steel pipe was found to be in almost the same condition as when laid, with the glossy surface of the Angus Smith's solution practically intact as originally applied 16 years ago.

Twenty-two years ago Vancouver actually risked its water supply with a 16-in. steel main only ⅛ in. thick. Inspection of this main last year demonstrated that the estimate of steel was not exaggerated, this very thin pipe being so little affected by corrosion that the engineer estimated its life to be worth at least another twenty-five years.

Thirty-three years ago the Kimberley Water Co., South Africa, laid down a wrought-iron water-supply main 14-in. and 18-in. diam., and ¼ in. thick, of which the present manager stated early this year: "With the exception of the portion which runs through a salt marsh, and which was replaced some three years ago, the pipe line is in as good a condition as when it was put down, and we do not anticipate any trouble for at least another twenty-five years."

I have selected the above cases for citation, because they represent pioneer work in four continents, and have led to the very general adoption of steel pipes throughout Australasia, Canada and South Africa, while the favorable experience of Bradford is now leading to the adoption of steel for the water-supply mains of some of the largest industrial centers in the country.

Years ago steel established itself as the material for high-pressure steam-boiler feed, and all other high-pressure service. In addition to the large number of steel, steam, feed, boiler and general service tubes to be found on every modern steamship (the boilers of the "Lusitania," "Mauretania" and "Aquitania" alone contain 100,000 fire tubes), the saving in weight effected by tubular construction has led to its adoption on board ship for many purposes where other sections and materials were formerly used.

Upon the general question of whether the experience of the last few years would warrant the conclusion that the weldless processes of tube making have now been developed to the stage that they will, in the immediate future, in competition with the welded tube, emerge triumphant, and that after all the difficulties which for so many years have accompanied these efforts continuously, I can only say this: In Germany, where the weldless process has been most sedulously pursued, the older methods of making tubes have not been developed and improved in any degree approaching to the way in which these older systems have been advanced by the Americans, and in this country.

I have had many opportunities of seeing tube works in Germany and in the United States, and I am convinced of this—that if the Germans had devoted as much labor of mind and as much of money to the improvement of their welding plants as they have upon experiments on weldless processes, their competition would have been much more severely felt here.

To summarize, the question is this: Can we produce by the old-established, known method of making tubes a tube as reliable as one made by the weldless process, and produce it so as to be able to sell it at the same price? In this country we can, and in America it is still possible. Commercially, the two processes have nowhere met each other on equal ground.

There has also existed, very generally, a theoretic prejudice in favor of the word "weldless," which has proved strong. In Germany the weldless process is universal. In this country and in the United States it is almost non-existent. Of course we all know how often we have been told that the Germans are beating us in everything, and how miserably incompetent and antiquated in their methods our manufacturers are, but we do not often hear the Americans branded as prejudiced fools, unable to take care of their own interests. The question is sometimes put thus: Is a tube any better for having a weld? No one can pretend that it is, and when a weldless tube can be produced of as reliable material and at about the same cost as a welded tube, the days of the latter will be numbered. That that day has not yet arrived is manifest, but that it is always growing nearer is certain.

A Year's Boiler Explosions

The annual report of the Marine Department of the Board of Trade upon the working of the Boiler Explosions Acts during the year ending June 30, 1914, is now before us.

The number of explosions, 68, and the number of lives lost thereby, 22, are both below the average, but the number of people injured, 74, is above the average. This is an exact reversal of the state of affairs set out in the immediately preceding report. Twenty-eight of the "boiler" explosions reported upon resulted neither in loss of life nor in injury to limb. The 96 casualties are thus attributable to 40 explosions. The report is distinguished by the record of an unusually disastrous explosion. On Aug. 26, 1913, a Beesley boiler, 22 years

old, failed at the works of Walter Scott, Limited, Hunslet, Leeds, killing 9 men and injuring 18. Investigation showed that the center flue tube had become worn out and that its first ring had collapsed for its full length and had fractured circumferentially. The insurance company, its assistant engineer and one of its inspectors were found to blame, and had to pay costs totaling £600.

Twenty-nine of the explosions occurred to "boilers" which were under the inspection of public bodies, but in 14 of these cases the explosions were not due to material defects, and therefore presumably could not have been guarded against by inspection. Of the causes of the explosions, deterioration or corrosion is most prominent, with 20 cases. Defective design or undue working pressure was responsible for 19, defective workmanship, material or construction for 12, ignorance or neglect of attendants for 9, and water hammer and miscellaneous causes for 4 each. As for the types of boilers which exploded, the horizontal multitubular was the greatest offender with 13 cases. Vertical boilers came next with 7. Tubes in steam ovens were responsible for 5, locomotive boilers for 4, while Lancashire, Cornish and other flue boilers resulted in 3 and water-tube boilers in 2 explosions. Steam pipes, stop-valve chests, etc., are classed as boilers in the acts, and these are debited with 11 explosions. There are three cases of pipes failing by fatigue caused by vibration. In one case it was a cast-iron feed-water pipe, 21 years old. In the two others the parts which failed were the main steam pipes, one being sixteen months old and the other but two months old. There are two cases of failure by fatigue caused by expansion and contraction. In one a cast-iron steam pipe 28 years old was concerned, and in the other the front end plate of a single-ended marine boiler 8½ years old was the part at fault.—"The Engineer," London.

ENGINEERING AFFAIRS

The Annual Dinners of The Atlantic City Association N. A. S. E. are always a success in point of attendance and speakers. The latest, given Mar. 20, was in keeping with all previous ones. The guests of the evening were Col. Lewis T. Bryant, Commissioner of Labor for New Jersey; George R. Starrs, of the Paterson, N. J., Board of Education; and A. L. Case, of the Engineers and Firemen's License Bureau. Other representative N. A. S. E. men and city officials were present.

ATLANTIC CITY N. A. S. E. AND GUESTS AT DINNER

Detroit Chief Engineers Dine—The second annual banquet of the Chief Engineers' Club of Detroit, Mich., was held at the Hotel St. Clair, Mar. 13, 1915.

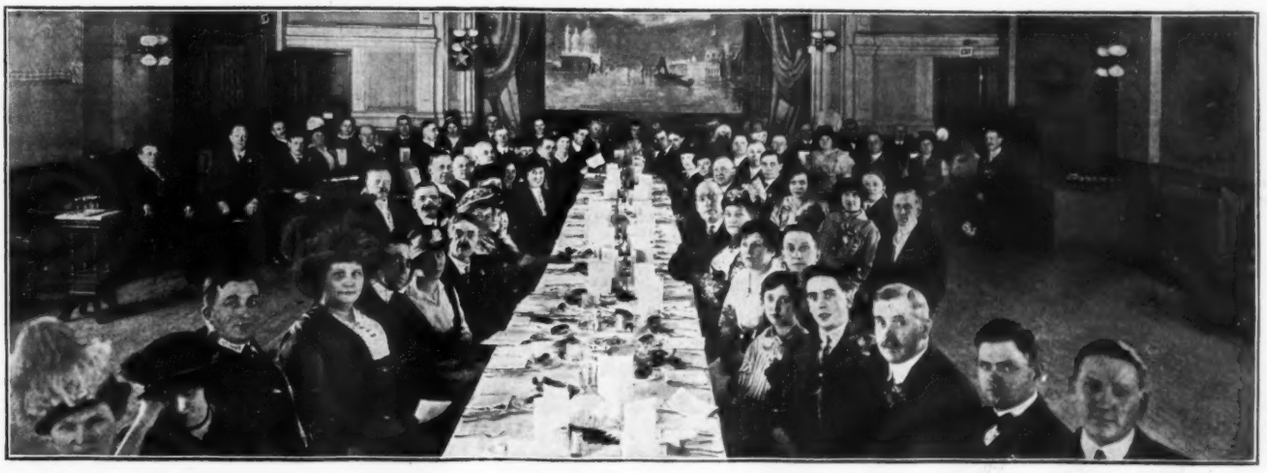
This club, which has been in existence only three years, is composed solely of chief engineers, and to be eligible to membership one must occupy the position of chief engineer in some steam plant. At the first annual banquet there were 42 present. This year 86 attended.

Immediately following the banquet there was a vaudeville entertainment given by stars from some of the leading Detroit theaters. The affair was under the direction of the entertainment committee, J. H. Roberts, chairman.

Following is a copy of the menu card:

BILL OF MATERIAL

Exciter
Bleached Fiber
Smooth On
Ball Bearings
Center Punches
Feed Water Agitators



DETROIT CHIEF ENGINEERS' CLUB DINNER

Aggressor — Carbon Brushes
Electrified Voltage
Aëroplanes
Gas Producers — Aggregate
Silencer — Circuit Breakers
Cement Pats
Refrigerator — Assorted Gaskets
Treated Feed Water — Fuel Testers

The executive committee for 1915 is as follows: Past-president, Charles Mery; president, John Gretzinger; vice-president, Alex Warner; secretary, H. C. Hayes; financial secretary, Edward Kahl; treasurer, Alex Kothe; marshal, F. J. Linck; assistant marshal, J. P. Field; entertainment committee, J. H. Roberts.

Ohio Adopts the A. S. M. E. Code

The following "Special Notice" has been issued by the chairman of the Ohio Board of Boiler Rules:

The Ohio Board of Boiler Rules at their meeting on Mar. 25, 1915, adopted the following resolution:

Until further notice, an Inspector holding a Certificate of Competency and a Commission authorizing him to inspect steam or hot-water boilers which are to be installed within the State of Ohio, is hereby authorized to inspect during construction and on completion stamp "OHIO STD" with Serial Number any boiler constructed in accordance with Rules formulated by the Boiler Code Committee as submitted to the Council of the American Society of Mechanical Engineers on February 13, 1915.

OHIO BOARD OF BOILER RULES,
H. V. NEFF, Chairman.

Mar. 29, 1915.

New Orleans Likely to Have Municipal Plant

That the City of New Orleans will have a municipal lighting plant, involving an ultimate outlay of from five to six million dollars, became apparent Mar. 15, when it was announced that engineers sent by George F. Bishop, of Cleveland, to make a survey of the proposition had completed their work and would soon make a report. There has been organized agitation for a municipally owned plant in the Southern city for many months and the New Orleans Railway & Light Co., which is at present supplying electrical energy for the city and private consumers, apparently isn't so powerful a factor in the city and state affairs as it used to be. The present street-lighting contract with the company expires Sept. 30 but, according to Commissioner E. E. Lafaye, whose department would have jurisdiction over the municipally owned plant, it will not be necessary to execute a new contract on that date or to make other arrangements, as the contract may be extended so as to give sufficient time for the construction of the municipal plant should that be decided upon.

BUSINESS ITEMS

Arthur D. Little, Inc., chemists and engineers, of Boston, are establishing an office in the Chemists' Building, 50 E. 31st St., New York.

Harry B. Aller now has charge of the Chicago territory of the Ohio Injector Co. He will handle its complete line of stationary power-plant equipment.

The Southwark Foundry & Machine Co., Philadelphia, Penn., is now actively engaged in the manufacture of hydraulic and steam hydraulic presses and has a considerable volume of this work in hand at the present time.

A correction—The advertisement of the Girtanner-Daviess Engr. & Contr. Co., St. Louis, Mo., in the Mar. 16 issue read "Sixteen installations since Jan. 1, 1915." This should have read "Twenty-two installations since Jan. 1, 1915."

G. L. Simonds & Co., 500 Gaff Bldg., Chicago, Ill., sales department of the Vulcan Soot Cleaner Co., has been awarded the contract for 18 Vulcan soot cleaners to be applied to 18 Keeler boilers to be furnished for the Illinois State Board of Administration.

A souvenir card being sent out by Yarnall-Waring Co., Chestnut Hill, Philadelphia, is a moving picture of the Simplex seatless blow-off valve. It is really a valve model and shows the construction and operation of the valve in detail. Sent on request.

The Hoppes Manufacturing Co., of Springfield, Ohio, recently made a sale of two 1,000,000 lb. per hr. Hoppes V-notch recording meters to the West Penn Traction Co., Pittsburgh, Penn. This is believed to be the largest installation of feed water metering equipment in the world and will be operated in connection with Hoppes feed water heaters.

The Lagonda Manufacturing Co., Springfield, Ohio, has just published a booklet entitled, "Lagonda Boiler Room Specialties." This booklet describes and illustrates the several types of Lagonda boiler tube cleaners with latest improvements and boiler quick repair tools. It also covers the Lagonda automatic cut-off valve and multiple strainers. Copy may be had on request.

The American Pulley Co., of Philadelphia, Penn., manufacturer of the celebrated "American" wrought-steel split pulley, has just completed arrangements for the opening of its own store at 119 Jackson St., Seattle, Wash., where it will carry a large and complete stock of pulleys for the accommodation of dealers in the Northwest. Archie Chandler, of Seattle, will represent the company in the distribution of its product among dealers on the Pacific Coast.

The Buffalo Forge Co., Buffalo, N. Y., has recently received contracts for heating and ventilating apparatus for the following public buildings: Private Ward Hospital, Wilkes-Barre, Penn.; Southwark Public School, Philadelphia, Penn.; Merchants National Bank, Richmond, Va.; Union High School, Alhambra, Calif.; High School, Compton, Calif.; El Paso Telephone Co., El Paso, Tex.; public school, Garden City, S. D.; Concordia Club, San Francisco, Calif.; Bloomsburg church, Bloomsburg, Penn.

Practically all the sizes and types of Edison Mazda multiple lamps are affected by reductions in list prices that were put into effect Apr. 1, by the Edison Lamp Works of General Electric Co. On the regular straight side and round bulb lamps, from the 10-watt to the 250-watt sizes, also on sign lamps, stereopticon lamps, etc., the reductions range from 3 to 20c. per lamp, according to the size.

On the gas-filled, multiple lamp of 100- to 1000-watt sizes, the reductions range from 50c. to $1 per lamp, the average reductions being between 20 and 25 per cent.

On Jan. 1, Lee H. Parker became president of the Spray Engineering Co., 93 Federal St., Boston, Mass., maker of Spray cooling equipment and air washers. Mr. Parker's experience in the engineering field has been unusually broad, he having severed a connection of 10 years with the Stone & Webster Co. to assume his new duties. Previous to this connection Mr. Parker had been for six years with the General Electric Co. and had also for some time represented large English engineering interests in South America. Mr. Parker was graduated from Cornell University in 1889 with the degree of M. E.

For the territory comprised by Kansas, Nebraska, southern part of Iowa and western part of Missouri, the McIntosh & Seymour Corporation, of Auburn, N. Y., has appointed as its agent Stanton A. Hadley, 621 Delaware St., Kansas City, Mo. Mr. Hadley is interested in the machinery-supply business of Hadley-Hudson Co., Kansas City, but in the future wil devote his whole time to the sale of McIntosh & Seymour Diesel type engines and steam engines and Gould pumps. Previously district manager for the Griscom-Russel Co., of New York, Mr. Hadley was prior thereto contractor, machinery salesman, erecting man and earlier with the A., T. & S. F. Ry.

The Manati Sugar Co., in the Province of Oriente, Cuba, with offices in New York City, has recently placed an order with the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Penn., for electric motors to drive all of its machinery in its new mill with the exception of the engine-driven rolls. This order covers a total of 32 alternating-current motors, having a total capacity of 1042 hp. All of the auxiliaries in this next extension of the Manati Sugar Co. will be motor driven, these auxiliaries including cane and bagasse conveyors, centrifugal pumps, crystalizers, agitators, etc. All of the new material will be in operation for the 1915-1916 grinding, and the electrical equipment will be delivered in time for this operation.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., APR. 1, 1915,

of Power, published weekly at New York, N. Y., required by the Act of August 24, 1912.

Editor, Fred R. Low, 10th Ave. at 36th St., New York, N. Y.
Managing Editor, Henry R. Cobleigh, 10th Ave. at 36th St., New York, N. Y.
Business Manager, William Buxman, 10th Ave. at 36th St., New York, N. Y.
Publisher, Hill Publishing Company, 10th Ave. at 36th St., New York, N. Y.
Owner, Hill Publishing Company, 10th Ave. at 36th St., New York, N. Y.

Owners of 1% or more of Stock Issued.

John A. Hill, 10th Ave. at 36th St., New York, N. Y.
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Fred S. Weatherby, 1600 Beacon St., Brookline, Mass.
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G. Eugene Sly, 50 Union Sq., New York, N. Y.
Frederick W. Gross, 215 E. 11th St., Erie, Pa.
Alfred E. Kornfeld, 10th Ave. at 36th St., New York, N. Y.
Emma B. Hill, 80 Munn Ave., East Orange, N. J.

The balance of the stock issued (less than 1% each) is owned by 71 employees, 4 ex-employees, and 14 others who are wives, daughters or relatives of employees.

Known bondholders, mortgagees, and other security holders holding 1 per cent. or more of total amount of bonds, mortgages or other securities. Mortgage on building held by Dime Savings Bank, Brooklyn, N. Y.

C. W. Dibble, Vice-President,
HILL PUBLISHING COMPANY.

Sworn to and subscribed before me this 31st day of March, 1915

RICHARD L. MURPHY,
Notary Public.
(My commission expires March 30, 1917.)